Geometric Constraints in Image Sequence and Neural Networks for Object Recognition

by

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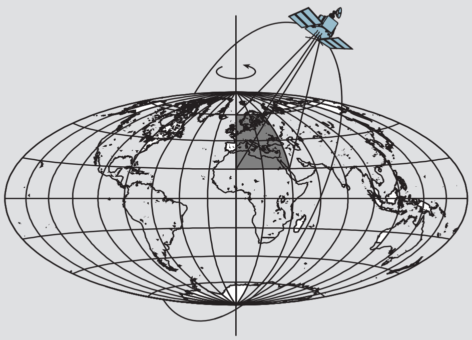

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Geometric Constraints in Image Sequences and Neural Networks for Object Recognition

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Geometric Constrains in Image Sequences and Neural Networks for Object Recognition

Summary

Spatially referenced mobile mapping image sequences contain rich information for applications such as transportation and utility management. Automatic object recognition and measurement from the images for reducing human operations and enhancing efficiency is a challenge in mobile mapping data processing. This report describes the research results of the project "Geometric Constrains in Image Sequences and Neural Networks for Object Recognition" supported by CFM/NASA (November 1996 – December 1997). Hopfield neural networks are applied to develop an algorithm for utility object recognition and photogrammetric measurements. Specifically, street light poles are modeled in the 3-D object space and compared with the corresponding features in the image sequences. The neurons of the net are formed by vector edge features from the model and images. The established Hopfield model is able to recognize light poles from a single image. It can also recognize and locate all light poles from the image sequences. It first recognizes all light pole features in the images. Secondly, corresponding light poles in stereo images are identified. Finally, the photogrammetric triangulation supplies 3-D positions of the poles in the object space. Such automation is particularly important for building special layers, for example traffic signs, fire hydrants, and road centerlines, to build GIS databases. The method developed has been successfully tested using mobile mapping image sequences. The major contributions of this research are

- Establishment of a Hopfield neural network for object recognition from mobile mapping image sequences using 3-D object models and 2-D image features,

- Application of the developed model to recognize and locate a specific light pole from a single image and from an image sequence, and to build a 3-D light pole database of all light poles,
- Understanding of the behavior of individual parameters of the neural network and their impact on the recognition results, and
- Development of the N^2M^2 system.

1 Introduction

Mobile mapping technology has been researched and demonstrated an innovative way for large-scale spatial data acquisition. Land vehicle based systems have been commercialized in last few years. A fully digital and real-time airborne mobile mapping system, AIMS (Airborne Integrated Mapping System), is in development at The OSU Center for Mapping (CFM). Examples of major challenging research areas include integrated sensor signal processing, automated triangulation, object recognition for automatic building of 3D databases and extracting features for triangulation, among others. A fundamental issue is image understanding of georeferenced mobile mapping data, which leads to the automatic reconstruction of 3-D objects from 2-D image features.

In existing mobile mapping data processing systems (Bossler et al. 1992, Li et al. 1994, Novak 1995, He 1996, Li 1997), fundamental photogrammetric and other measuring functions, image processing functions (global and local image enhancement), edge detection, area-based matching and zooming, and GIS data input/output functions have been developed. The systems were used for collecting infrastructure data, transportation data and other objects in GIS. Despite of its advantages, the potential of Mobile Mapping technology is currently limited by the following factors:

- Most of data processing is manual,
- The great scale variation causes difficulty in position measurements and object recognition, and
- Geometric constraints provided by the sensors are not fully utilized.

In order to overcome the limits, research on automatic feature extraction and 3-D object recognition have to be conducted. Based on this motivation and the CFM's research priorities, the objectives of this research are:

- To study the correspondence between extracted image features and 3-D object spatial models,
- To develop methods for automatic recognition of specific objects,
- To apply neural networks for object recognition,
- To integrate geometric constraints into neural networks, and
- To develop methods for recognizing and locating objects using multiple images.

2 Methodology

Object recognition and determination of object location have been based on principles of pattern recognition and photogrammetry. To date, object recognition is most efficiently performed by human operators, although measurements can be automated by digital image matching techniques. The human image understanding process has not been fully understood, because of the complexity of the human brain. Therefore, it is so far not possible to simulate the biological process of object recognition by a computer system. Computational approaches have been used in neural networks. It was hoped that a vector based neural network method would solve some of the problems faced by traditional raster based pattern recognition methods when applied in mobile mapping data processing. For example, the recognition algorithm would have to handle extremely large image sequences of mobile mapping data. Furthermore, raster patterns of the same object may vary form image to image because of great scale changes, imaging geometry etc.

Based on above, we were to find a new method for object recognition from mobile mapping image sequences in order for a computer to simulate vision process of a human operator. Artificial neural network was chosen to implement this approach.

2.1 Basic principle of neural networks

A neural network is "a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs" (Caudill 1989). Unlike popular conception, neural networks do not mimic operations of the human brain. They can be thought of consisting of inter-connected "neurons" linked together by synapses. When enough of the input synapses send a signal into a neuron, it 'fires', causing signals to be sent down its output synapses, which in turn cause other neurons to fire, and so on.

Neural networks are typically organized in layers. Layers are made up of a number of interconnected "nodes" or neurons, which contain an "activation function". An "input layer" communicates to one or more "hidden layers" where the actual processing is done via a system of the weighted "connections". The hidden layers then link to an "output layer" where the answer lies. The structure of an artificial neuron is shown in Figure 1.

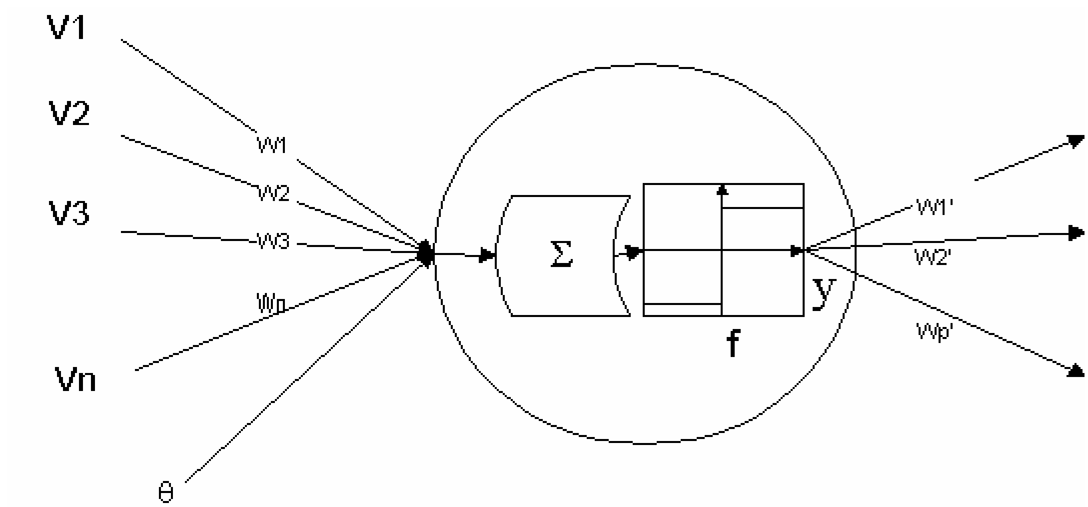


Figure 1. The structure of artificial neuron

The output y of the neuron is expressed as

$$y = f((\sum_i W_i V_i) - q), \quad (1)$$

with

- f - transfer function
- W_i - weight (mimic the strength of synapse)
- V_i - input signal
- q - the threshold.

In comparison to the computer process, human brain has a massively parallel structure, a large knowledge database, and distributed memory. It has capabilities of fuzzy reasoning and learning. Neural networks can be classified into four groups:

a) Supervised learning network: which involves target values for the network outputs;
b) Unsupervised learning network: which does not involve the using of target data. Instead of learning an input-output mapping, the goal may be to model the probability distribution of the input data or to discover clusters or other structure in the data;
c) Associate learning network: which does not involve the whole target data and conclude the result; and
d) Optimization application network: which requires the minimization of an objective function subject to some constrains.

In a system of d), the object recognition from the mobile mapping data can be treated as an optimization problem to identify an object from different georeferenced stereo images. Hopfield neural network is one of the networks in this group.

2.2 Survey and analysis of neural network software packages

Most neural network methods for pattern recognition are based on raster data. Training data (knowledge or object models) and target data (data to be compared to) are both stored in the raster data format. This requires more computer memory and computational time. Furthermore, the features compared are low-level features so that robustness is often an issue. Improved methods use vector data with objects defined according to various knowledge levels.

Six neural network software systems, namely NeuroSolutions, Neural Networks at your Fingertips, Attrasoft Boltzmann Machine, Windows Neural Networks (WinNN), THINKS-Neural Networks, and SNNS were surveyed. The software packages are developed by the companies or universities. A number of them are available on web pages. Five systems with the Hopfield Model or multilayer processing functions, including NeuroSolutions, Neural Networks at your Fingertips, Attrasoft Boltzmann Machine, Windows Neural Networks (WinNN), and THINKS-Neural Networks for Windows, were tested. The majority of the systems is based on back-propagation learning and is used for pattern recognition. The survey and test results of the five systems are listed in Table 1.

The neural network objective or energy function is fixed in most software packages reviewed. It cannot be modified, nor additional constraints can be added if source code is not provided. Only two packages, NeuroSolutions and Neural Networks at your Fingertips (NN), came with source code. However, the package handles raster elements instead of vector features as we have in this project. Furthermore, constrains are also vector based and thus, cannot be efficiently integrated into the existing packages. It was then decided that a new software system be developed in this project. The following is the results of the neural network software system review.

<u>NeuroSolutions</u>

There are six levels of NeuroSolutions.

1) The Educator, the entry level version, is intended for those who want to learn about neural networks and work with MLPs. Up to 512 neurons per layer and up to 2 hidden layers.
2) The Users version extends the Educator with a variety of neural models for static pattern recognition applications. Up to 16K neurons per layer and up to 6 hidden layer.
3) The Consultants version offers enhanced models, which support dynamic pattern recognition, time-series prediction and process control problems.

Table 1. The characteristics of the neural network software packages

	NeuroSolutions	**Neural Networks at your Fingertips (NN)**	**Attrasoft Boltzmann Machine(ABM)**	**Windows Neural Networks (WinNN)**	**THINKS**
Developer or Company	NeuroDimension, Inc.	Karsten Kutza	Attrasoft	Dr. Yaron Danon	Logical Designs Consulting, Inc.
Function	Six levels and allow you to implement your own neural models	Ready-to-reuse software simulators for eight popular architectures	Learn by adapting its synaptic weight to changes in the surrounding	Back-propagation learning and multiple document interface application	With eight learning algorithms and eight Architectures
Hopfield Model	Yes	Yes	Yes(The Boltzman machine)	No	Yes
Single or Multi-layer	Both	Single	Single	Both (2 to 5)	Both (3 hidden layer)
Environment	Win 3.1, 95, NT	DOS	Win 95	Win 3.1	Win 95
Source code	Professional level supports ANSI C++ source code	Support source for each architecture	No	No	No
Image data processing	No	No	No (has to be draw on text file by hands)	No	No
Data input	Text file or import from spreadsheet	Text file	Text file	Text file	Input from software function or import from spreadsheet
Language	C++	C	No	Interface by Visual Basic and calculate by Fortran DLL	Support Windows Dynamic Link Library (DLL)
Graphics	Yes	No	Yes	Yes	Yes

4) The Professional version adds ANSI C++ compatible code generation, allowing you to embed NeuroSolutions' algorithms into your own applications (including learning). Furthermore, this version allows any simulation prototyped within NeuroSolutions to be run on other platforms, e.g. faster computers or embedded real time systems.
5) The Developer versions allow you to extend the functionality of NeuroSolutions by integrating your own neural network, preprocessing, control, and input/output algorithms.
6) NeuroSolutions for Excel is an Excel Add-in that integrates with any of the six levels of NeuroSolutions to provide a very powerful environment for manipulating your data, generating reports, and running batches of experiments.

Systems are required to meet the follows minimum specifications: Operating System of Windows NT 3.51/4.0 or Windows 95, 8MB RAM (16MB recommended), 20MB free hard disc space (6MB for the abbreviated version), video of 640x480 with 256 colors (800x600 with 16M colors recommended).

<u>Neural Networks at your Fingertips</u>

The characteristics of this software package are listed in Table 2. A Hopfield model uses a set of training data to calculate weight values of each neuron in an objective function: Sum = $\sum W * V_i$, where V_i=-1 if Sum<threshold, otherwise V_i=1. Each model has independent code. The user can modify the code to develop own programs.

Table 2. Characteristics of Neural Networks at your Fingertips
(Abstract from web page: http://www.geocities.com/CapeCanaveral/1624/)

Network	Application	Description
ADALINE Adaline Network	Pattern Recognition Classification of Digits 0-9	The Adaline is essentially a single-layer back propagation network. It is trained on a pattern recognition task, where the aim is to classify a bitmap representation of the digits 0-9 into the corresponding classes. Due to the limited capabilities of the Adaline, the network only recognizes the exact training patterns. When the application is ported into the multi-layer back propagation network, a remarkable degree of fault-tolerance can be achieved.
BPN Back propagation Network	Time-Series Forecasting Prediction of the Annual Number of Sunspots	This program implements the now classic multi-layer back propagation network with bias terms and momentum. It is used to detect structure in time-series which is presented to the network using a simple tapped delay-line memory. The program learns to predict future sunspot activity from historical data collected over the past three centuries. To avoid over fitting, the termination of the learning procedure is controlled by the so-called stopped training method.
HOPFIELD Hopfield Model	Auto associative Memory Associative Recall of Images	The Hopfield model is used as an auto associative memory to store and recall a set of bitmap images. Images are stored by calculating a corresponding weight matrix. Thereafter, starting from an arbitrary configuration, the memory will settle on exactly that stored image, which is nearest to the starting configuration in terms of Hamming distance. Thus given an incomplete or corrupted version of a stored image, the network is able to recall the corresponding original image.
BAM Bi-directional Associative Memory	Hetero associative Memory Association of Names and Phone Numbers	The bi-directional associative memory can be viewed as a generalization of the Hopfield model to allow for a Hetero associative memory to be implemented. In this case, the association is between names and corresponding phone numbers. After coding the set of exemplars, the network, when presented with a name, is able to recall the corresponding phone number and vice versa. The memory even shows a limited degree of fault-tolerance in case of corrupted input patterns.
BOLTZMAN Boltzmann Machine	Optimization Traveling Salesman Problem	The Boltzmann machine is a stochastic version of the Hopfield model; whose network dynamics incorporate a random component in correspondence with a given finite temperature. Starting with a high temperature and gradually cooling down, allowing the network to reach equilibrium at any step, chances are good, that the network will settle in a global minimum of the corresponding energy function. This process is called simulated annealing. The network is then used to solve a well-known optimization problem: The weight matrix is chosen such that the global minimum of the energy function corresponds to a solution of a particular instance of the traveling salesman problem.
CPN Counter propagation Network	Vision Determination of the Angle of Rotation	The counter propagation network is a competitive network designed to function as a self-programming lookup table with the additional ability to interpolate between entries. The application is to determine the angular rotation of a rocket-shaped object, images of which are presented to the network as a bitmap pattern. The performance of the network is a little limited due to the low resolution of the bitmap.
SOM Self-Organizing Map	Control Pole Balancing Problem	The self-organizing map is a competitive network with the ability to form topology-preserving mappings between its input and output spaces. In this program the network learns to balance a pole by applying forces at the base of the pole. The behavior of the pole is simulated by numerically integrating the differential equations for its law of motion using Euler's method. The task of the network is to establish a mapping between the state variables of the pole and the optimal force to keep it balanced. This is done using a reinforcement learning approach: For any given state of the pole the network tries a slight variation of the mapped force. If the new force results in better control, the map is modified, using the pole's current state variables and the new force as a training vector.
ART1 Adaptive Resonance Theory	Brain Modeling Stability-Plasticity Demonstration	This program is mainly a demonstration of the basic features of the adaptive resonance theory network, namely the ability to plastically adapt when presented with new input patterns while remaining stable at previously seen input patterns.

Attrasoft Boltzmann Machine

The Boltzmann Machine is a neural network whose behavior can be described statistically in terms of a very simple rule. This rule is as follows: let a synaptic connection from neuron i to neuron j, at time t, be $M[i, j][t]$, then the connection at the next time $t+1$ t+1, $M[i, j][t+1]$, is $M[i, j][t+1]$ = M[i,j][t] + a(q[i,j]-p[i, j] + ...)

where a is a small number; q[i,j] represents the correlation between neuron i and neuron j from the training data; and p[i,j] represents a self-created correlation between neuron i and neuron j. The Boltzmann Machine supports up to 65,000 external (input/output) neurons. It learns by interactive training and continues to learn by interactive retraining. It also works for any pattern recognition problem; for example, image recognition. The system includes more than twenty examples, including one with more than 4,000 classes. It is capable of learning more than 4,000 characters in 60 seconds, a speed unachievable by humans. It recognizes 1 of the 4,000 characters in 0.5 seconds and supports translation and scaling symmetries.

The Neural Network Capabilities include:

- Character Recognition: To recognize a character, a network of 1000-neurons or so is required. A character can be represented by a 20-by-20-pixel image (400 neurons). The rest of the neurons can be used to identify up to 600 different characters in 1-neuron-1-class mode, or about 180,000 characters in 2-neuron-1-class mode.
- Signature Recognition: To recognize a signature, a network of 3000-neurons or so is required. A signature can be represented by a 20-by-100-pixel image (2000 neurons). The rest of the neurons can

be used to identify up to 1000 different signatures in 1-neuron-1-class mode, or about 500,000 signatures in 2-neuron-1-class mode.

- Image Recognition: To recognize an image, a network of 20,000-neurons or so is required. An image can be preprocessed to the size of 100-by-100-pixel (10,000 neurons). The rest of the neurons can be used to identify up to 10,000 different images in 1-neuron-1-class mode, or about 50,000,000 images in 2-neuron-1-class mode.

Windows Neural Networks (WinNN)

Windows Neural Networks (WinNN) is a windows based Neural Network (NN) simulator with back-propagation learning. The following is a brief description of feed forward NNs that helps understand the way WinNN calculates and adjust the weights. A neural network in its basic form is composed of several layers of neurons: an input layer, one or more hidden layers and an output layer. Each layer of neurons receives its input from the previous layer or from the network input. The output of each neuron feeds the next layer or the output of the network. Mathematically the network computes:

1) The output of the hidden layer (treating the bias as another input): h(j)=Sum(w(i,j)*i(i), i=1, 3) and s(j)=f(h(j)),
2) For the output layer calculate: h'(k)=Sum(w'(j,k)*s(j), j=1, 3) and O(k)=f(h'(k)), where: i(i) are the network inputs, O(k) are the network inputs, W(i,j) represents the weight connecting neutron i in layer 1 to neutron j in layer 2, W'(j,k) represents the weight connecting neutron j in layer 2 to neutron k in layer 3, and f(x) is the neuron transfer function, for example, a sigmoid: f(x)=1/(1+exp(-x)).

Training such a network involves using a database of examples, which are values of the input and output of the NN. The NN would learn by adjusting the weights to minimize the error of the outputs. The error function is the objective of the minimization procedure and defined as: SSE=Sum(Sum((t(p,k)-O(p,k))^2, k=1, Kmax), p=1, Pmax) where O(p,k) is the NN output k for pattern p, and t(p,k) is the output training pattern p for output k. The reported RMS Error is calculated as $RMS = sqrt(SSE / P\max)$. WinNN uses a simple back propagation algorithm to adjust the weights. This algorithm is an iterative one. WinNN trains in BATCH mode with a variable EPOCH length. That is it sums the weight adjacent over all the training patterns in an epoch and then adjusts the weights.

THINKS-Neural Networks for Windows

This software program supports eight Neural Network Learning Rules: Back Propagation (BPN), Quick Propagation (QP), Jacobs Enhanced Back Propagation, Kohonen Winner Take All, Simulated Annealing (SA), Recurrent Back Propagation, Learning Vector Quantization, and Cascade Correlation. The available architecture types are Multi layer Normal Feed Forward, Multi layer Full Feed Forward, Total Recurrent, Prior Recurrent, Cascade, and Cascade Recurrent. The network error type determines how error is computed. Since the goal of neural network training is to minimize error, the network error type method affects weight adjustments and specifically how outliers are handled.

2.3 Basic principle of Hopfield neural network for mobile mapping

A Hopfield neural network has the follows key behaving elements:

- It is completely described by a state vector $V = (v_1, v_2, ..., v_n)$ of all neurons;
- There are a specific set of stable states $V_s = (v_1, v_2, ..., v_n)$ that correspond to the stored patterns; and
- The system evolves in time from any arbitrary starting state V_0 to a stable state V_S by decreasing its energy E.

A Hopfield neural network is built from a single layer of neurons (units), with feedback connections from each unit to every other unit (except itself). The change of the unit states is associated to an energy function. A Hopfield neural network for vector image matching uses a two-dimensional array for storing V. The rows represent features of the vector image with an object used as a template or an object model defined a priori. The columns represent features of another image where the object defined will be recognized. Figure 2 shows an example of a two-dimensional state array.

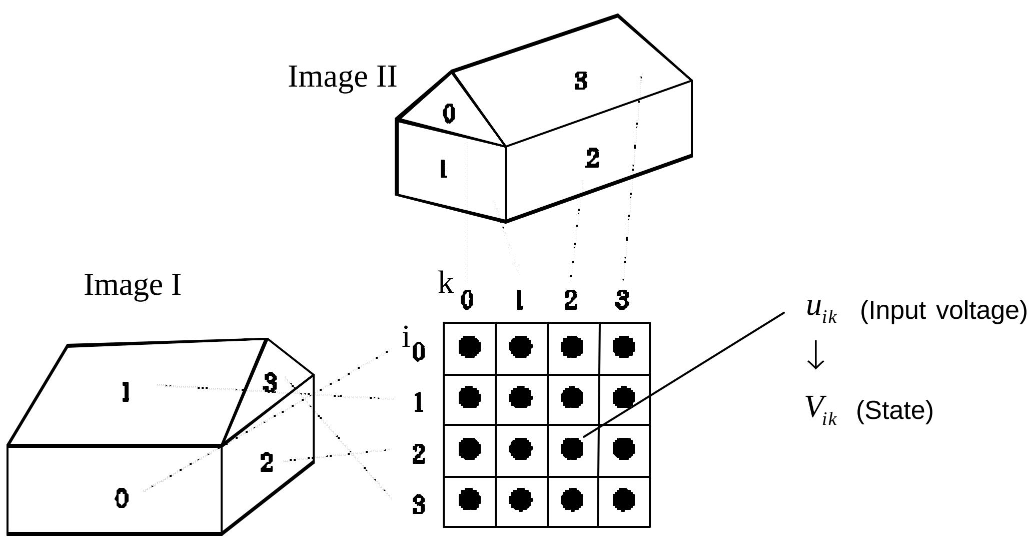


Figure 2. A Hopfield neural network of two-dimensional array for storing V

Face features in Image I are numbered i=1,2,3 and 4. These in Image II are j=1,2,3 and 4. Faces 2 and 3 may not be the same faces of 0 and 1 in image II because of the orientation of cameras. The Hopfield neural network is to find the corresponding faces between the images. Such correspondences are represented in the state array of V where a high correspondence between face i in image I and face j in Image II is expressed by a high state value v_{ij} of neuron (i, j). The final state V_s is obtained by an optimization of an energy function defined as

$$E = -\sum_i \sum_k \sum_j \sum_l C_{ikjl} V_{ik} V_{jl} + \sum_i (1 - \sum_k V_{ik})^2 + \sum_k (1 - \sum_i V_{ik})^2 \qquad (2)$$

where the first term is a compatibility constraint; the second and third terms are the uniqueness constraints. v_{ij} converges to 1.0 if face i in Image I matches face k in Image II. Otherwise, it is greater than or equal to 0. C_{ikjl} is the strength of interconnection between a neuron (raw i and column k) and another neuron (row j and column l):

$$C_{ikjl} = \sum_n W_n * F(x_n, y_n) \qquad (3)$$

where

x_n is the n-th measuring feature of the unit (row i and column k),

y_n is the n-th measuring feature of the unit (row j and column l),

W_n is a weight, $\sum W_n$ =1 and the transfer function is

$$F(x, y) = \begin{cases} 1 & if\ |x - y| < q \\ -1 & \text{otherwise} \end{cases}.$$

q is a threshold value. It is the measuring features that represent characteristics of objects to be recognized. Examples of the measuring features may be shape similarity, orientation consistency, and conformance to constraints. If measuring features from the two images do not match, through the threshold, the transfer function, and the weights, the energy function in Equation (2) will be penalized by a large value. Otherwise, the features will have a less contribution to the energy function. In an application, it is very important to design the detailed measuring features, the weights, and threshold values. The terms of energy are separated into two groups and are given different weights. Group 1 is the first term. Group 2 contains the second and third terms. Two weight coefficients p_1 and p_2 ($p_1+p_2=1$) are given to the groups:

$$E = p_1[-\sum_i \sum_k \sum_j \sum_l C_{ikjl} V_{ik} V_{jl}] + p_2[\sum_i (1-\sum_k V_{ik})^2 + \sum_k (1-\sum_i V_{ik})^2]. \tag{4}$$

If we increase the weight of group 2, p_2, it will enhance the effect of $\sum(1-\sum V)^2$. In this case, only one feature of row or column will be matched. A high value of p_1 will allow a feature in a row to match multiple features in columns. The optimal state of the conjugate relations between the two groups is reached when the minimum energy value is obtained. The minimization of Equation (4) is performed by updating the state array V iteratively.

The above basic model is used to recognize street light poles from the mobile mapping data.

2.4 Enhancement of the accuracy of recognized objects using multiple images

Once an object is recognized in stereo images, its 3-D coordinates can be calculated by a photogrammetric intersection of two conjugate image features. The accuracy and reliability of the coordinates can be enhanced if multiple (more than two) images are used. The basic principle of the multiple image intersection using the mobile mapping data is shown in Figure 3. In this simplified case, there are three pairs of stereo exposure centers and one object position.

The object may appear in several images in the sequence. The strategy of automatic determination of the 3-D object location from multiple images is described in the following.

Step 1. The desired object is automatically recognized in all individual images by the Hopfield neural network. This is completed by comparing the object image features with the known model in the 3-D object space.

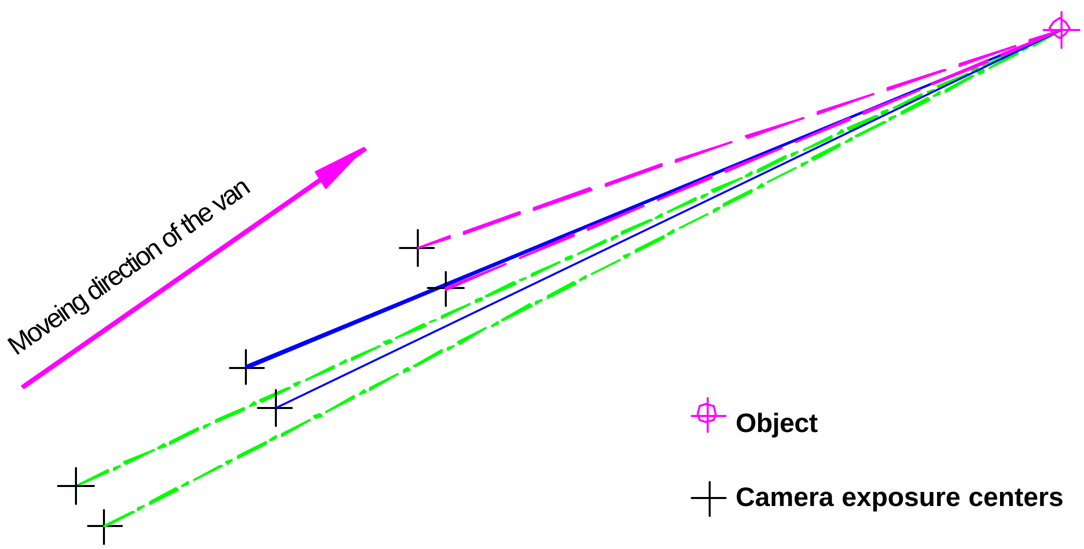


Figure 3. Multiple image intersection

Step 2. Conjugate image features that are recognized in Step 1 are automatically determined in all images. The combinations of stereo pairs are restricted to any two images within three immediately adjacent exposure stations. The result of this step is 3-D locations of objects calculated by photogrammetric triangulation. So far the triangulation is done pair wise. A simultaneous estimation of the location from all available images should be used in the future.

Step 3. A thematic database is built automatically by applying the algorithm through all the images in the sequence.

3. Hopfield Neural Network for Mobile Mapping Data Processing

In this research, it was decided that street light poles are our targeted objects for recognition. In the 3-D object space, a light pole is defined as a cylinder with a diameter of 21.2cm and a length of 6.795m. The values were obtained by manual photogrammetric measurements of light poles from the images of the project area. It should stand vertically not far from the mobile mapping van. Such a light pole is then back projected onto the images and used to find out images features similar to them. Conjugate light pole image features are recognized and used to calculate 3-D locations.

3.1 Measuring features and weights

The 3-D light pole model is defined in the object space. It is back projected onto the image space using the camera orientation parameters. The measuring features evaluate differences between the back projected pole lines and image features. The Hopfield network makes judgement if the object (light pole) described by the model exists in the images through Equation (4). The measuring features used in this research can be separated into two groups, namely local features and relational features. They are both defined in the image space. The local features include

- Length (λ): length of a line,
- Azimuth (α): azimuth of a line (measured clockwise from the x-axis),
- Distance (δ): distance between two lines, and
- Local Gradient $(+1 \text{ or } -1)_{ik}$: east-west gradient (+1 for the case from background to the interior of the line pair, -1 otherwise).

The relational features are

- Relative angle (β): angle from the first line to the line linking the middle points of the line pair (clockwise),
- Ratio (δ/λ): width-height ratio, and
- Relative Gradient $(+1 \text{ or } -1)_{ikjl}$: relative gradient defined similar to the local gradient feature.

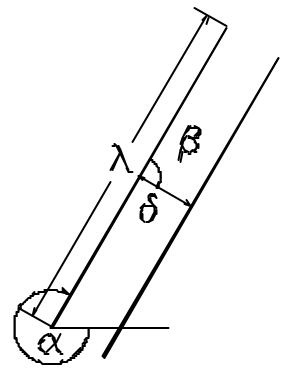


Figure 4. Definition of a pair of lines

The Hopfield neural network uses different combinations of the above features in the model to recognize poles in different situations. To recognize a specific light pole with a known position in the object space, we use the measuring features of

- Length of lines (scale variant),
- Azimuth of lines (close to vertical), and
- Local Gradient (compatibility of a line pair to form a pole).

The weights of p_1 and p_2 of the two energy groups are initially set equal in the energy function. Numerical values of the measuring features can be calculated and analyzed to determine thresholds (q) and weights (W_n). A partial differential equation is used to link the updated neuron states and the energy decrease/increase in Equation (4). The equation is solved iteratively.

To recognize all light poles regardless positions, the measuring features used are:

- Width-length ratio (scale invariant),
- Azimuth of lines (close to scale invariant), and
- Relative Gradient (compatibility of a line pair to form a pole, scale invariant)

3.2 Data sets

Data in the object space: The first set of data describes the light poles. A light pole is defined as a cylinder with a given length and radius. The approximate coordinates of the bottom central point are estimated using camera orientation parameters. The second set of data is camera orientation parameters. They come from the mobile mapping data and are used for transformation between the object and image spaces.

Data in the image space: The line features in images are supposed to be extracted by digital image processing. At this time, the operator manually extracts them. Each line has a label ID, coordinates of its vertices, a starting node and an end node, and a gradient of the line (1 for the case that the left-hand side is darker than the right and -1 otherwise).

3.3 Algorithm for light pole recognition

The following steps depict the algorithm developed in this project for recognizing the light poles from mobile mapping data:

Step 1. Create a matrix with a dimension of I×M (I is the number of back projected model lines and M is the number of line features in the image) to store neuron states V. Figure 5 shows an example of extracted lines from an image and a pair of lines back-projected from a light pole model in the object space.

Step 2. Set the initial states of V as

$$V_{ik}^{0} = g(u_{ik}^{0}) = [1 + \exp(-2u_{ik}^{0} / u_{0})]^{-1}$$

$$u_{ik}^{0} = u_{init} + d = u_{0} + d$$

where $u_0 = 0.002$ and d is a random number uniformly distributed between 0.1 u_0 and +0.1 u_0.

u_{ik} is called input voltage.

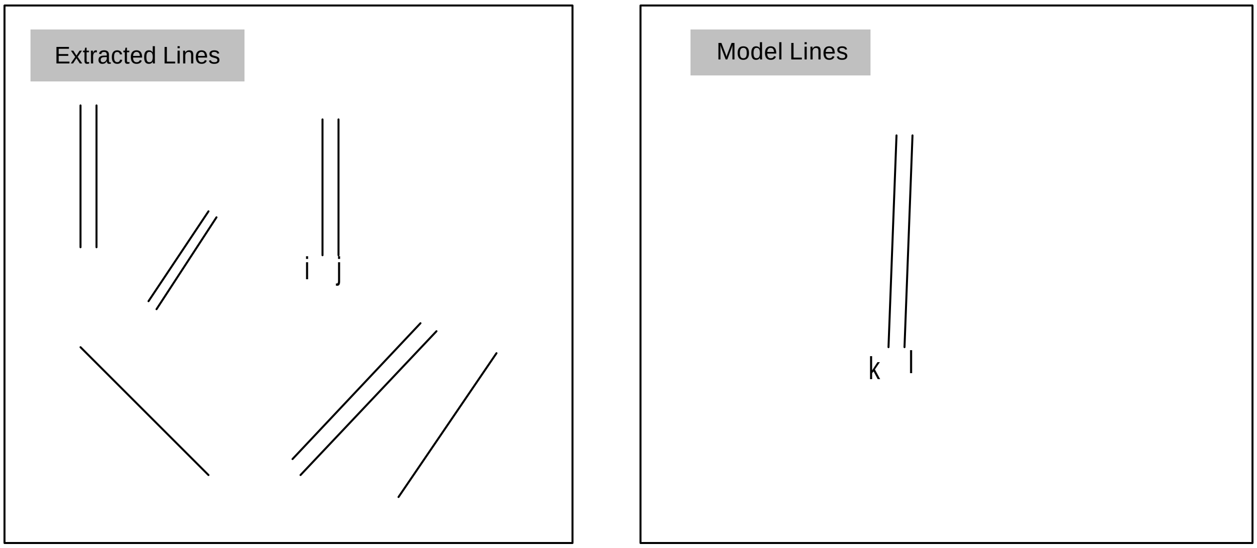


Figure 5 Extracted lines from an image and back-projected lines from a light pole model

Step 3. Build C coefficients (see Equation (4))

$$
\begin{aligned}
C_{ikjl} &= W_1 * F(d_{I_i,I_j}, d_{M_k M_l}) + W_2 * F(a_{I_i}, a_{M_k}) + W_3 * F(a_{I_j}, a_{M_l}) \\
&+ W_4 * F(l_{I_i}, l_{M_k}) + W_5 * F(l_{I_j}, l_{M_l}) + W_6 * F(Grad_{I_i}, Grad_{M_k}) \\
&+ W_7 * F(Grad_{I_j}, Grad_{M_l}) + W_8 * F(Grad_{I_i}, Grad_{M_k}, Grad_{I_j}, Grad_{M_l})
\end{aligned}
$$

The features with subscriptions of I and M are those of the model and image, respectively; d is the distance between two lines; a_i means the azimuth of a line: arctan $[\,(X_E^i - X_B^i)/(Y_E^i - Y_B^i)\,]$; l_i stands for the length of a line: sqrt $[(X_E^i - X_B^i)^2 + (Y_E^i - Y_B^i)^2]$; Grad defines the gradient of lines; and F is a transfer function in Equation (3); further, W_i are weight factors of the features, $\sum W_i = 1$. They are set as $W_2 = W_3$, $W_4 = W_5$, $W_6 = W_7 = W_8/2$. The weights are adjusted according to the objects to be recognized and the images. Note that F(x,y)=0 if i=j or k=l.

Step 4. Set the current number of iteration as t=1 and the limit of iterations as n.

Step 5. Update the values of u_{ik} and V_{ik}

for (i=0; i<m; i++)

for (k=0; k<n;k++)

$$u_{ik}^{t+1} = u_{ik}^{t} + \tfrac{1}{6}(K_1 + 2*K_2 + 2*K_3 + K_4)$$

where

$$K_1 = h\times f(u_{ik}^{t}) = h\times(\sum_j\sum_l C_{ikjl}V_{jl}^{t} - \sum_l V_{il}^{t} - \sum_j V_{jk}^{t} - u_{ik}^{t}/1+2)$$

$$K_2 = h\times f(u_{ik}^{t} + \tfrac{1}{2}K_1)$$

$$K_3 = h\times f(u_{ik}^{t} + \tfrac{1}{2}K_2)$$

$$K_4 = h\times f(u_{ik}^{t} + K_3)$$

h is a constant (h=0.0001)

Step 6. $V_{ik}^{t+1} = g(u_{ik}^{t+1})$ and repeat Step 5 until t ≥ n. Update $V_{ik} = \begin{cases} 1 & \text{if } V_{ik} > 0.5 = q_1 \\ 0 & otherwise \end{cases}$

4. Results and Analysis

4.1 Test data sets

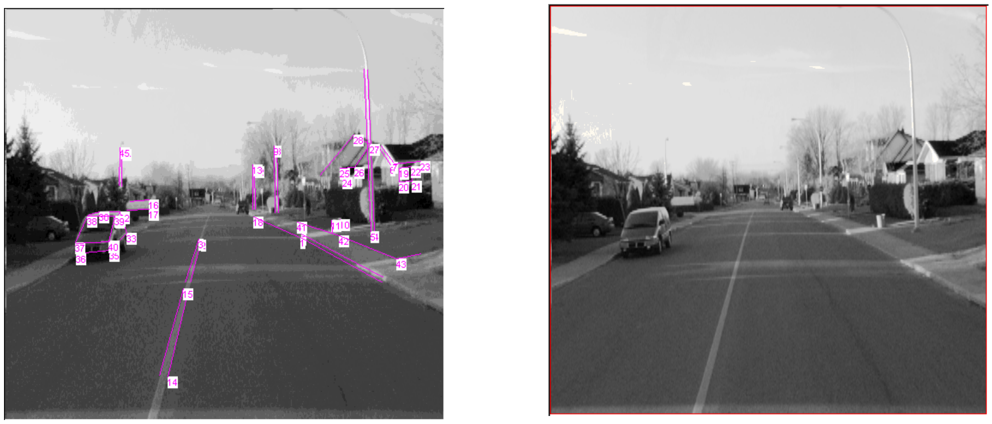
Two test data sets acquired by two different Mobile Mapping Systems are used. The data sets include digital stereo image sequences, positions and attitudes of the cameras (internal and external orientation parameters of each image). One system provides the format of color digital images (720 pixels × 400 pixels). The other system has the format of gray scale images (512 pixels×480 pixels). For reducing the volume of the images, we transferred the color images to gray scale images. Figure 6 shows a sample of a pair of digital stereo images.

Figure 6. A digital stereo image pair

As another example, the labeled line features overlaid on the original image and the original itself are shown in Figure 7. The extracted image lines and the back projection of the 3-D pole model are shown in Figure 8. Among the image lines, lines 4 and 5, 8 and 9, 12 and 13, and 44 and 45 are pairs of edge lines of light poles. Lines 44 and 45 represent a partial light pole.

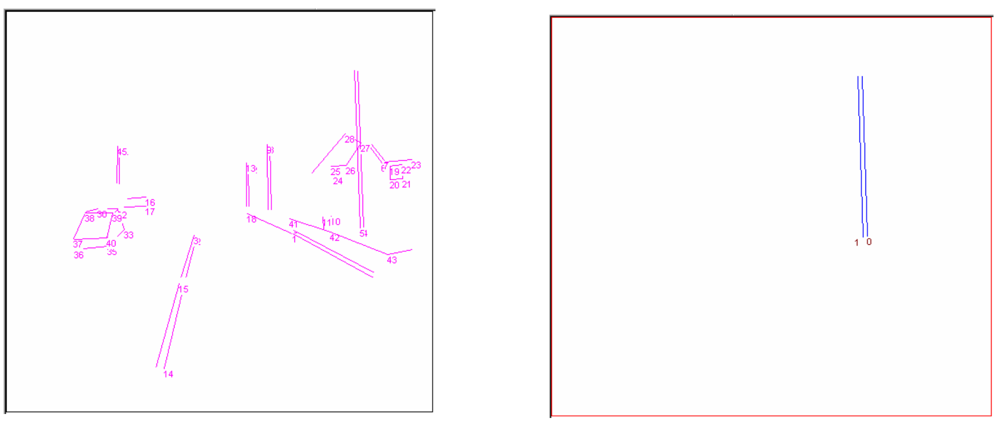
4.2 Experiment and analysis

Once the model is defined, the most important thing is to determine the parameters in the model. In this section, we describe the results of three experiments, namely recognition of a specific light pole, recognition of all light poles, and location of recognized light poles using multiple images. In the first two experiments, we discuss the effect of the parameters in the neural network, including thresholds and weights. In the third experiment, accuracy of reconstructed light poles and the location distribution will be analyzed.



Labeled line features   Original Image

Figure 7. Labeled line features and the original image



Extracted line features   Back projection of the model

Figure 8. Extracted lines and the back-projection of the model

The software system developed in this project allows the user to change the parameters though the system interface shown in Figure 9.

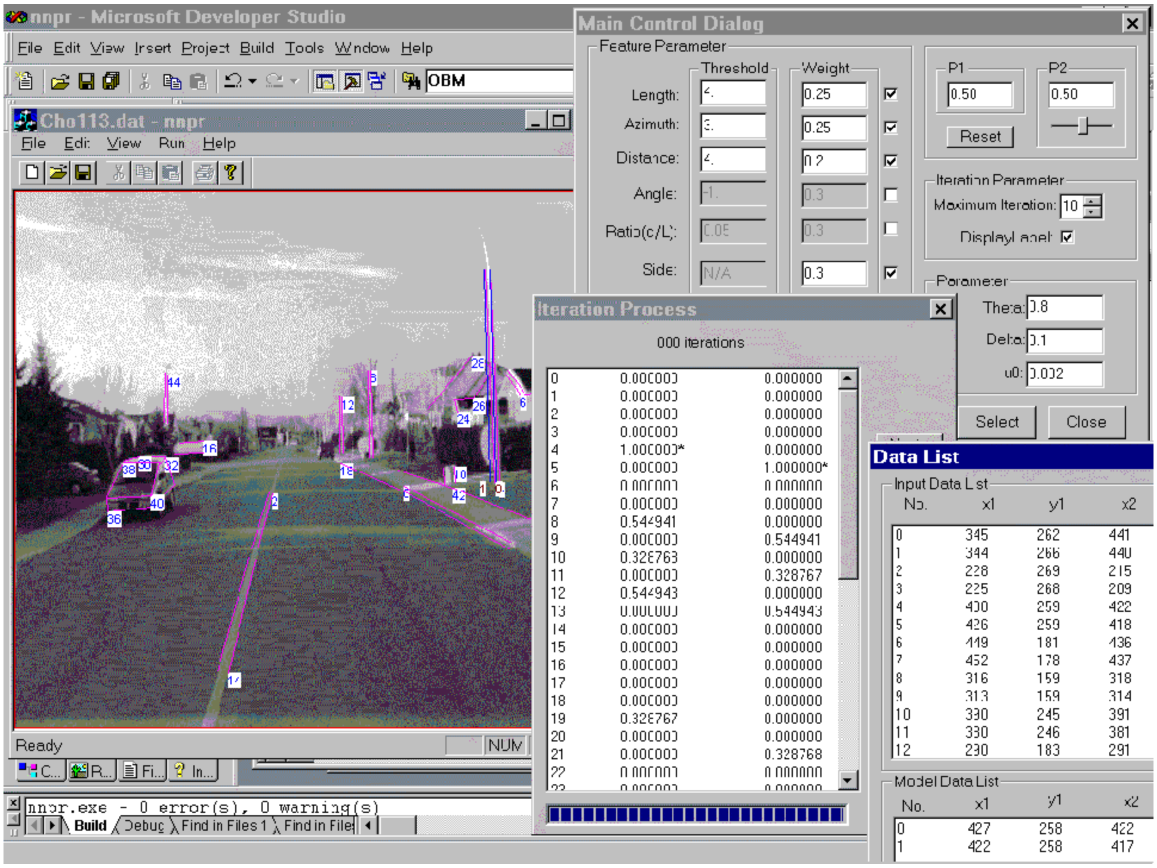


Figure 9 User interface of the developed Neural Network System for object recognition

After examining the parameters and the recognition results in a trail test, we set Theta (θ)=0.8, Delta (δ)=0.1, and u_0=0.002. The maximum number of iterations is 1000. The unit of threshold of λ and δ are pixel. The unit of threshold of α is degree.

Experiment I. Recognition of a specific light pole

The location of the light pole (represented by lines 4 and 5 in Figure 7 and 8) is estimated in the object space using camera orientation parameters, considering that the light pole is vertical at an elevation close to that of the van and it is close to the right curb. Lines 0 and 1 are artificial line features back projected from the 3-D light pole model (Figure 8). In ideal case, the neural network should find its conjugate image pole lines 4 and 5 in the image. In the process, the Hopfield network generates a layer of 2 by 46 neurons to match 2 model lines with 46 image lines from the image. Table 3 listed states of neurons indicating the recognition result.

Each measuring feature (length, azimuth, or local gradient) has an equal weight. The weight of each neural element was also assigned with an equal weight. The following parameters were used:

Threshold of λ=4.0	Weight of λ=0.25
Threshold of α=3.0	Weight of α=0.25
Threshold of δ=4.0	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ=0.05	Weight of δ/λ=0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.46	0	0.22	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.49	0	0.26

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.46	0	0	0	0	0	0	0.22	0	0	0	0
Neuron state (Matching with model line 1)	0	0.49	0	0	0	0	0	0	0	0.26	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.22	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.46	0		
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0.49		

Table 3. Final states (v_{ik}) of the neurons (recognition of a specific pole)

The state V_{ik} gives a value ranging from 0 to 1, with 1 indicating a perfect match between the model line i and image line k, and 0 being no match at all between them. Observing Table 3, the system has clearly recognized the image pole lines 4 and 5 since $V_{0,4} = V_{1,5} = 1$. Other image pole lines, such as 8-9, 12-13, and 44-45, have relatively high state values (close to 0.5) because they are similar to the model lines 0-1 (Figure 8) except the length. An experiment is also carried out to observe the behavior of system in response to changes of the parameters. This is accomplished by changing the selected parameter(s) and executing the program each time. The effect of such changes is reflected in the final states of the neurons.

Example 1. Changing threshold λ from 4.00 to 2.00

The change of the threshold λ from 4.00 to 2.00 means a more strict constraint in accepting candidates in terms of the length of image lines. This resulted in a decrease of the state value in Table 4, except $V_{0,4}$ which remains the same. $V_{1,5}$ reduced from 1 to 0.75, which is still a high value. The parameters used are:

Threshold of λ=2.00	Weight of λ=0.25
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ=0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.41	0	0.18	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.75	0	0	0	0.46	0	0.26

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.41	0	0	0	0	0	0	0.18	0	0	0	0
Neuron state (Matching with model line 1)	0	0.46	0	0	0	0	0	0	0	0.26	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.18	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.41	0		
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0.46		

Table 4. Final states V of the neurons (threshold λ changed to 2.00)

Example 2. Changing threshold λ from 4.00 to 6.00

The threshold λ is changed to 6.00 to allow candidates to have lines with different lengths. The parameters used are:

Threshold of <u>λ=6.00</u>	Weight of λ=0.25
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.46	0	0.22	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.49	0	0.26
	12	13	14	15	16	17	18	19	20	21	22	23
	0.46	0	0	0	0	0	0	0.22	0	0	0	0
	0	0.49	0	0	0	0	0	0	0	0.26	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.22	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.46	0		
	0	0	0	0	0	0	0	0	0	0.49		

Table 5. Final states V of the neurons (threshold λ changed to 6.00)

The results listed in Table 5 do not have significant difference from Table 3 which used threshold λ=0.4. Comparing the results with the extracted lines in Figure 8, it is clear that the length differences between model lines 0-1 and image lines 8-9, 12-13, and 44-45 are significant. Therefore, the threshold change did not cause any great effect on the result.

<u>Example 3. Changing threshold α from 3.00 to 1.00</u>

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.25
Threshold of <u>α=1.00</u>	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

The change of the threshold from 3.0 to 1.0 means increased constraints on verticality of the lines. This resulted in the more acceptances of light poles in Table 6. The model lines of 0-1 matched both 4-5 and 8-9. A major difference between 4-5 and 8-9 is their lengths. But the weights for length λ and azimuth α are the same 0.25. The threshold of α is tighter (more important). Thus, the significance of the length is reduced and the system accepted both 4-5 and 8-9 as matches of model lines 0-1.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.87	0	0	0	0.87	0	0	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.97	0	0	0	0.97	0	0
	12	13	14	15	16	17	18	19	20	21	22	23
	0.4	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0	0		
	0	0	0	0	0	0	0	0	0	0		

Table 6. Final states V of the neurons (threshold α changed to 1.00)

Example 4. Changing threshold α from 3.00 to 5.00

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.25
Threshold of α=5.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

Setting α=5.00 gives lower restrict to verticality of lines, so that the fact that 8-9 is much shorter than the model lines 0-1 is counted heavily again. This explains why $V_{0,8}$ and $V_{1,9}$ decreased to 0.45 in Table 7.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.45	0	0.23	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.45	0	0.23

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.45	0	0	0	0	0	0	0.23	0	0	0	0
Neuron state (Matching with model line 1)	0	0.45	0	0	0	0	0	0	0	0.23	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.23	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.45	0		
Neuron state (Matching with model line 1)	0.23	0	0	0	0	0	0	0	0	0.45		

Table 7. Final states V of the neurons (threshold α changed to 5.00)

<u>Example 5: Changing threshold δ from 4.00 to 2.00</u>

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.25
Threshold of α=3.00	Weight of α=0.25
Threshold of <u>δ=2.00</u>	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

Changing the threshold δ from 4.00 to 2.00 does not affect the result (Table 8). This is because the distances between image pole lines are smaller than 2.00 pixel.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.58	0	0.28	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.61	0	0.32
	12	13	14	15	16	17	18	19	20	21	22	23
	0.28	0	0	0	0	0	0	0.28	0	0	0	0
	0	0.32	0	0	0	0	0	0	0	0.32	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.28	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.28	0		
	0	0	0	0	0	0	0	0	0	0.32		

Table 8. Final states V of the neurons (threshold δ changed to 2.00)

Example 6. Weight distribution: p_1=0.6 and p_2=0.4

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.25
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.6	p_2=0.4

p_1 and p_2 are weights balancing the two energy groups in Equation (4). Increasing p_1 allows a model line to match multiple images lines, while increasing p_2 encourages a unique match between the model lines and image lines. However, p_1 and p_2 are constrained by $p_1 + p_2 = 1$. Since p_1=0.6 is greater than p_2=0.4 in this example, we see that in addition to high values of $V_{0,4} = 1$ and $V_{1,5} = 1$, $(V_{0,8}, V_{1,9})$, $(V_{0,12}, V_{1,13})$, and $(V_{0,44}, V_{1,45})$ are relatively large.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.83	0	0.2	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.85	0	0.24
	12	13	14	15	16	17	18	19	20	21	22	23
	0.83	0	0	0	0	0	0	0.2	0	0	0	0
	0	0.85	0	0	0	0	0	0	0	0.24	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.2	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.83	0		
	0	0	0	0	0	0	0	0	0	0.85		

Table 9. Final states V of the neurons (p_1=0.6 and p_2=0.4)

Example 7. Weight distribution: p_1=0.4 and p_2=0.6

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.25
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.25
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.00
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.4	p_2=0.6

Setting p_1 and p_2 the other way around, p_1=0.4 and p_2=0.6, it requires that each model line matches only one image line. Because the model lines 0-1 are most similar to image lines 4-5, the corresponding neuron states $v_{0,4}$ and $v_{1,5}$ are 1. Conversely, the states of other neurons are low. The effect of adjusting the ratio of p_1 and p_2 is very significant.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	0.32	0	0.2	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	0.34	0	0.24

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.32	0	0	0	0	0	0	0.2	0	0	0	0
Neuron state (Matching with model line 1)	0	0.34	0	0	0	0	0	0	0	0.24	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.2	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.32	0		
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0.34		

Table 10. Final states V of the neurons (p_1=0.4 and p_2=0.6)

Experiment II. Recognition of all light poles

In this experiment, it is expected that the model lines will match all image pole lines. By observing the image pole lines, it is clear that the lengths of the pole lines are different because of the perspective projection. In order for the model lines to match all the pole lines, the contributing measuring features should not include scale variant items. Thus, the weights of λ(length) and δ(width) were set to 0. The applied measuring features include α (azimuth), λ/δ (width-length ratio), and gradient.

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.00
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.00
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.50
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.98	0	0	0	0.98	0	0.02	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.98	0	0	0	0.98	0	0.02

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.98	0	0	0	0	0	0	0.02	0	0	0	0
Neuron state (Matching with model line 1)	0	0.98	0	0	0	0	0	0	0	0.02	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.02	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.98	0		
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0.98		

Table 11. Final neuron states using scale invariant measuring features

According to Table 11, the neural network recognized all light poles correctly by indicating matches of model lines 0-1 with image pole lines of 4-5, 8-9, 12-13, and 44-45. Similar to Experiment I, effects of each parameter on the final recognition results are investigated by changing values of parameters and by observing the final neuron states.

<u>Example 1. Changing threshold of α from 3.00 to 1.00</u>

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.00
Threshold of <u>α=1.00</u>	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.00
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ =0.50
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

Changing of the threshold of α from 3.00 to 1.00 requires the more strict constraint of azimuths of the image pole lines (ranging from 89^0 to 91^0). The image pole lines were digitized on screen and include digitizing errors. The strict azimuth constraint eliminated the match possibilities of image pole lines of 4-5 and 44-45.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	1	0	0	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	1	0	0
	12	13	14	15	16	17	18	19	20	21	22	23
	1	0	0	0	0	0	0	0	0	0	0	0
	0	0.87	0	0	0	0	0	0	0	0	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0	0		
	0	0	0	0	0	0	0	0	0	0		

Table 12. Final neuron states by changing α to 1.00

Example 2. Changing threshold of α from 3.00 to 5.00

The parameters used are:

Threshold of λ=4.00 Weight of λ=0.00
Threshold of α=5.00 Weight of α=0.25
Threshold of δ=4.00 Weight of δ=0.00
Threshold of β=-1.00 Weight of β=0.00
Threshold of δ/λ=0.05 Weight of δ/λ=0.50
Threshold of gradient=0 Weight of gradient=0.25
p_1=0.5 p_2=0.5

Making the constraint of the threshold of α looser ($\alpha=5.0^o$) in this example leads to matches of the model lines with all image pole lines. Thus, all poles are recognized.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.95	0	0	0	0.95	0	0.05	0
Neuron st ate (Matching with model line 1)	0	0	0	0	0	0.95	0	0	0	0.95	0	0.05

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.95	0	0	0	0	0	0	0.05	0	0	0	0
Neuron st ate (Matching with model line 1)	0	0.95	0	0	0	0	0	0	0	0.05	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.05	0
Neuron st ate (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.95	0		
Neuron st ate (Matching with model line 1)	0.05	0	0	0	0	0	0	0	0	0.95		

Table 13. Final neuron states by changing α to 5.00

<u>Example 3. Changing threshold of δ/λ from 0.05 to 0.02</u>

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.00
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.00
Threshold of β=90 or 270	Weight of β=0.00
Threshold of <u>δ/λ =0.02</u>	Weight of δ/λ =0.50
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

Increasing the constraint of the threshold of δ/λ to 0.02 means that long image poles will be preferred. As the result the partial pole 44-45 and the farthest pole 12-13, which may be covered on the bottom were not matched because of their large width-length ratios.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	1	0	0.29	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	1	0	0.33

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.29	0	0	0	0	0	0	0.29	0	0	0	0
Neuron state (Matching with model line 1)	0	0.33	0	0	0	0	0	0	0	0.33	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.29	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.29	0		
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0.33		

Table 14. Final neuron states by changing δ/λ to 0.02

Example 4. Changing threshold of δ/λ from 0.05 to 0.08

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.00
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.00
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.08	Weight of δ/λ=0.50
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.5	p_2=0.5

The looser constraint of the threshold of δ/λ=0.08 resulted in the same result as δ/λ=0.05. All poles are recognized.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.98	0	0	0	0.98	0	0.02	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.98	0	0	0	0.98	0	0.02
	12	13	14	15	16	17	18	19	20	21	22	23
	0.98	0	0	0	0	0	0	0.02	0	0	0	0
	0	0.98	0	0	0	0	0	0	0	0.02	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.02	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	0.98	0		
	0	0	0	0	0	0	0	0	0	0.98		

Table 15. Final neuron states by changing δ/λ to 0.08

Example 5. Weight distribution: p_1=0.6 and p_2=0.4

The parameters used are:

Threshold of λ=4.00	Weight of λ=0.00
Threshold of α=3.00	Weight of α=0.25
Threshold of δ=4.00	Weight of δ=0.00
Threshold of β=90 or 270	Weight of β=0.00
Threshold of δ/λ =0.05	Weight of δ/λ=0.50
Threshold of gradient=0	Weight of gradient=0.25
p_1=0.6	p_2=0.4

Similar to example 6 in Experiment I, the high value of p_1=0.6 allows multiple matches between the model lines and the image pole lines. The four image pole lines have the state value 1. But other image lines of 10, 11, 19, and 21 were assigned relatively high state values also.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	1	0	0	0	1	0	0.57	0
Neuron state (Matching with model line 1)	0	0	0	0	0	1	0	0	0	1	0	0.67
	12	13	14	15	16	17	18	19	20	21	22	23
	1	0	0	0	0	0	0	0.57	0	0	0	0
	0	1	0	0	0	0	0	0	0	0.67	0	0
	24	25	26	27	28	29	30	31	32	33	34	35
	0	0	0	0	0	0	0	0	0	0	0.57	0
	0	0	0	0	0	0	0	0	0	0	0	0
	36	37	38	39	40	41	42	43	44	45		
	0	0	0	0	0	0	0	0	1	0		
	0	0	0	0	0	0	0	0	0	1		

Table 16. Final neuron states with p_1=0.6 and p_2=0.4

Example 6. Weight distribution: p_1=0.4 and p_2=0.6

The parameters used are:

Threshold of λ=4.00 Weight of λ=0.00
Threshold of α=3.00 Weight of α=0.25
Threshold of δ=4.00 Weight of δ=0.00
Threshold of β=90 or 270 Weight of β=0.00
Threshold of δ/λ =0.05 Weight of δ/λ =0.50
Threshold of gradient=0 Weight of gradient=0.25
p_1=0.4 p_2=0.6

The high weight of p_2=0.6 discourages the multiple matches. As the result, all the state values are lower. Because only scale invariant measuring features are used and the measuring feature values of the image pole lines are all within the thresholds, the image pole lines are still the ones, which best match the model lines. However, their state values are low, although relatively higher than others.

ID of extracted line	0	1	2	3	4	5	6	7	8	9	10	11
Neuron state (Matching with model line 0)	0	0	0	0	0.55	0	0	0	0.55	0	0.18	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0.57	0	0	0	0.57	0	0.21

ID of extracted line	12	13	14	15	16	17	18	19	20	21	22	23
Neuron state (Matching with model line 0)	0.55	0	0	0	0	0	0	0.18	0	0	0	0
Neuron state (Matching with model line 1)	0	0.57	0	0	0	0	0	0	0	0.21	0	0

ID of extracted line	24	25	26	27	28	29	30	31	32	33	34	35
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0	0	0.18	0
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0	0	0

ID of extracted line	36	37	38	39	40	41	42	43	44	45		
Neuron state (Matching with model line 0)	0	0	0	0	0	0	0	0	0.55	0		
Neuron state (Matching with model line 1)	0	0	0	0	0	0	0	0	0	0.57		

Table 17. Final neuron states with p_1=0.4 and p_2=0.6

Experiment III. Objet recognition using multiple images:

In this experiment, a sequence of 25 images from a mobile mapping survey line are used (Figure 11). Exposure stations of stereo images taken simultaneously by the mobile mapping system are indicated by the + + symbol, and the exposure station are numbered from 102 to 127. The two stereo images at the same station are distinguished by its station number with a L (left) or R (right) extension, for example, 112L and 112R. Six light poles, from LP1 to LP6, are marked by symbols. The exposure station or images are listed for each light pole that appears in the listed images. Using the method described in Experiment II, the extracted image pole lines in all images are recognized. Considering effective baselines of different possible combinations of stereo pairs, for each pole, only three stations that are closest to the pole are used. For example, light pole LP2 in Figure 11 is covered by exposure stations 102, 103, 104, 105, 106, 107, and 108. However, only three stations (106, 107, and 108) are used to determine the position of the pole.

To start the location process, the station closest to the pole (in this example, 108) is first considered. In either image at station 108, for instance 108L, the longest image pole line pair is automatically selected. The image coordinates of the pole bottom and pole top are known as (x_b, y_b) and (x_t, y_t). Their corresponding coordinates in the object space are (X_B, Y_B, Z_B) and (X_T, Y_T, Z_T). Assume that the pole is vertical and the pole length is l, we have $X_T = X_B$, $Y_T = Y_B$, and $Z_T = Z_B + l$. Since the camera orientation parameters are known, there are four collinearily equations:

$$x_b = -f\,\frac{a_{11}(X_B - X_0) + a_{12}(Y_B - Y_0) + a_{13}(Z_B - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B - Z_0)},$$
$$y_b = -f\,\frac{a_{21}(X_B - X_0) + a_{22}(Y_B - Y_0) + a_{23}(Z_B - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B - Z_0)},$$
$$x_t = -f\,\frac{a_{11}(X_B - X_0) + a_{12}(Y_B - Y_0) + a_{13}(Z_B + l - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B + l - Z_0)}, \text{ and}$$
$$y_t = -f\,\frac{a_{21}(X_B - X_0) + a_{22}(Y_B - Y_0) + a_{23}(Z_B + l - Z_0)}{a_{31}(X_B - X_0) + a_{32}(Y_B - Y_0) + a_{33}(Z_B + l - Z_0)}. \qquad (5)$$

In the above four equations, there are three unknowns (X_B, Y_B, Z_B) which can be solved by a least squares adjustment. The coordinates are then used to back project a 3-D pole model to the right image 108R. The two back projected model lines are then used to match the image pole lines on the right image using the method of the neural network described in Experiment I. Once the correct image pole lines in the right image are found, the precise position of the pole in the object space can be calculated by a photogrammetric intersection. To obtain a more precise location of the pole in the object space by multiple image intersection, the pole location calculated from the station 108 is used to back project the 3-D model onto all images of three stations (106L, 106R, 107L, 107R, 108L, and 108R). The neural network is used again to find corresponding image pole lines in the selected stereo images of various combinations. At this stage, the coordinates of the pole from different stereo pair are calculated and compared. Intersections using all qualified images will be implemented in the future. In this way, all light poles in the image sequence can be recognized and located subsequently.

Table 18 presents the coordinates of the light pole LP2 calculated by 11 combinations of stereo image pairs. The corresponding plot of the locations of the pole is in Figure 12. Ideally, the locations should be within a small area. However, because of the relatively short effective baselines the calculated locations are spread along the track (Figure 12). In the middle of all the locations is the point calculated from the stereo pair of 108L and 108R which is the station closest to the pole. Two image pairs, namely 107L & 108R and 107R & 108R, are far away from the average location. It should be noted that their intersection angles and their effective baselines are both very small. Thereby the large errors are caused.

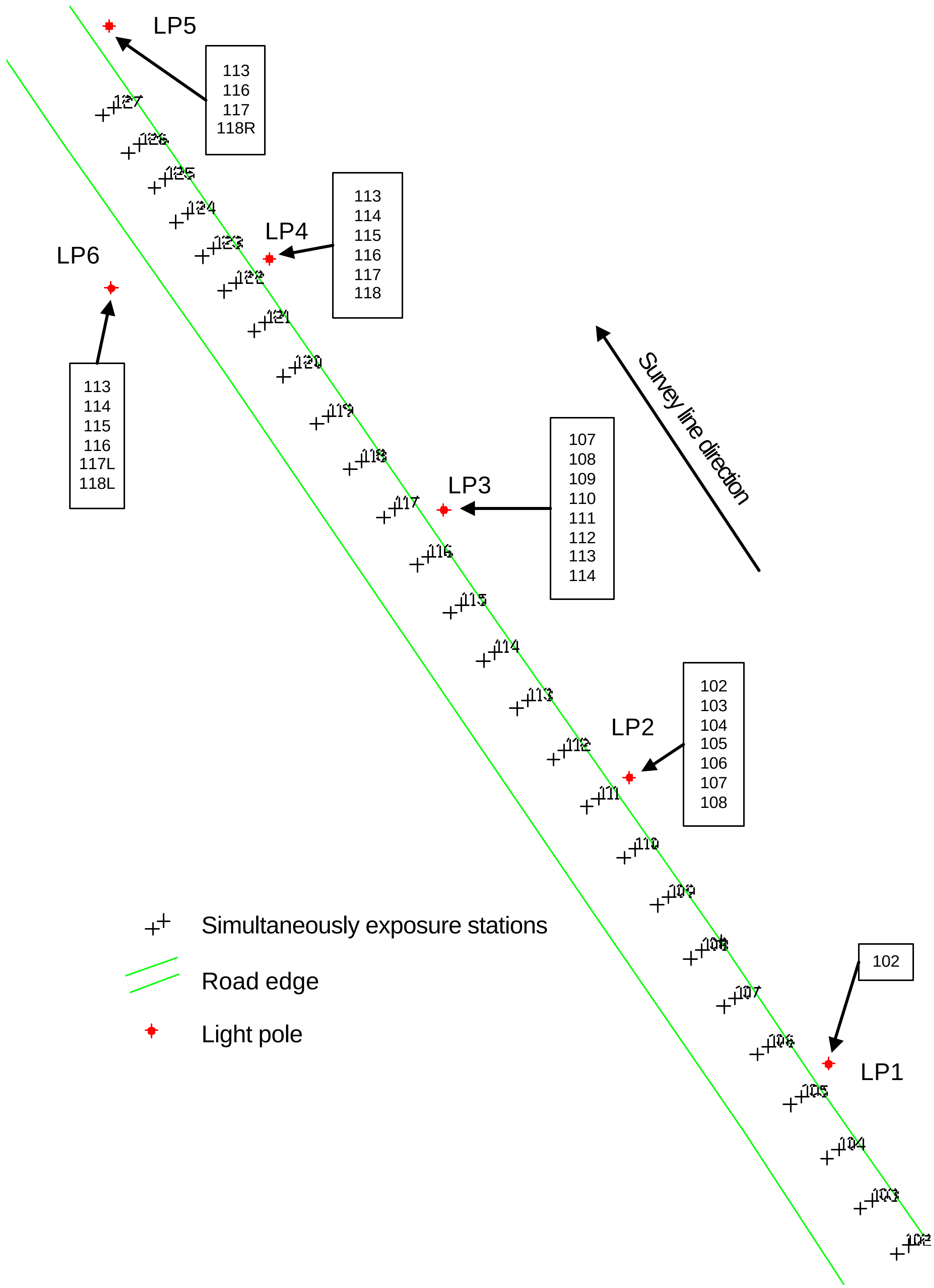


Figure 11. Object recognition from an image sequence

The locations from three intra stereo pairs nb(108L & 108R, 107L & 107R, 106L & 106R) are close to the average location. Further research should be conducted to set up criteria for selecting images for a multiple image intersection. If only two images are used for intersection, an optimization should be performed using the intersection angle as the criteria (Li et al. 1996).

Intersection Pair	X coord.	Y coord.	Z coord.	X (center)	Y (center)	Z (average)	delta X	delta Y
106L & 106R	278834.435	5047545.569	-0.058					
	278834.250	5047545.375	-0.042	278834.342	5047545.472	-0.050	0.269	-0.541
107L & 107R	278834.668	5047545.145	-0.048					
	278834.520	5047544.986	-0.036	278834.594	5047545.066	-0.042	0.017	-0.134
108L & 108R	278834.581	5047544.999	-0.018					
	278834.441	5047544.843	-0.004	278834.511	5047544.921	-0.011	0.100	0.010
106L & 107L	278834.982	5047544.372	0.031					
	278835.209	5047543.313	0.089	278835.096	5047543.842	0.060	-0.485	1.089
106R & 107R	278834.845	5047544.771	-0.060					
	278835.225	5047543.509	0.014	278835.035	5047544.140	-0.023	-0.424	0.791
107L & 108L	278833.931	5047546.947	-0.131					
	278833.802	5047546.715	-0.114	278833.867	5047546.831	-0.123	0.744	-1.900
107R & 108R	278833.530	5047547.540	-0.244					
	278833.399	5047547.310	-0.224	278833.465	5047547.425	-0.234	1.146	-2.494
106L & 107R	278835.506	5047543.302	0.055					
	278834.722	5047544.463	-0.001	278835.114	5047543.883	-0.001	-0.503	1.048
106R & 107L	278834.675	5047545.113	-0.044					
	278834.730	5047544.465	-0.005	278834.703	5047544.789	-0.025	-0.092	0.142
107L & 108R	278835.972	5047541.801	0.200					
	278835.823	5047541.713	0.208	278835.898	5047541.757	0.204	-1.286	3.174
107R & 108L	278834.164	5047546.227	-0.117					
	278834.034	5047546.015	-0.100	278834.099	5047546.121	-0.109	0.512	-1.190
		Average		278834.611	5047544.931	-0.032		
		σ		0.675	1.567	0.110		

Table 18. The coordinates of the light pole calculated by various stereo

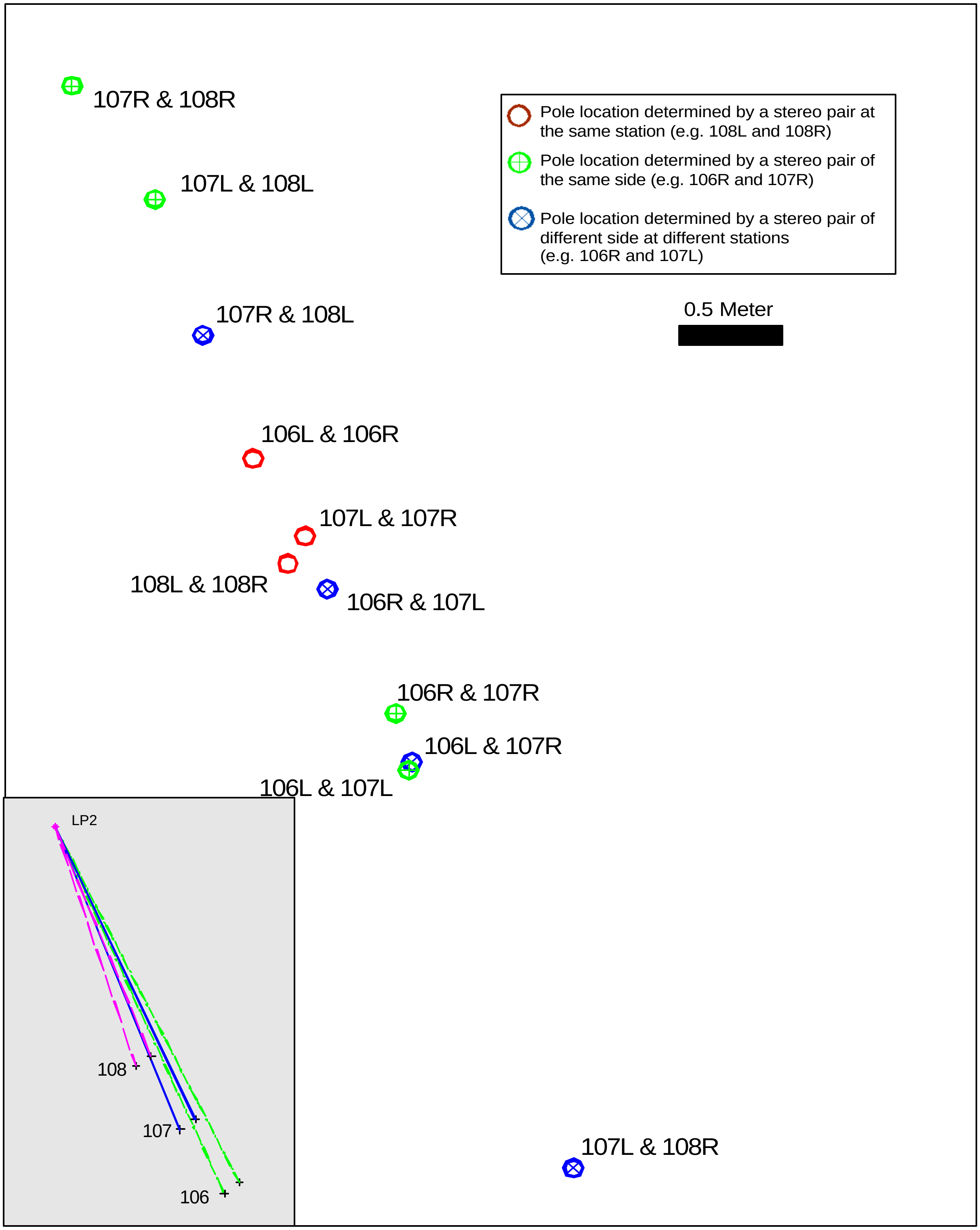


Figure 11. Distribution of the light pole locations calculated by various stereo image pair combinations provided by the neural network

5.Conclusions

In this project, an algorithm of Hopfield neural network for object recognition from mobile mapping image sequences is developed. A software system "N^2M^2" (Neural Networks for Mobile Mapping) has been developed to implement the algorithm. The system is based on the C++ programming language in the Microsoft Windows 32bits environment. The program flow chart is depicted in Appendix A. Its source code is listed in Appendix C, and available on the tape. The major contributions of this research are

- Establishment of a Hopfield neural network for object recognition from mobile mapping image sequences using 3-D object models and 2-D image features,
- Application of the developed model to recognize and locate a specific light pole from a single image and from an image sequence, and to build a 3-D light pole database of all light poles,
- Understanding of the behavior of individual parameters of the neural network and their impact on the recognition results, and
- Development of the N^2M^2 system.

This research focuses on the automatic recognition of light poles. The measuring features of the model are the key part for characterizing objects and are object dependent. If different objects are to be recognized new measuring features should be defined and integrated in the model. Further challenge will be how to represent our knowledge about the object to be recognized in the model parameters. This will lead to a special learning process of the neural network. We believe that such research will result in a generic method for the optimal determination of thresholds and weight values in the model for different object.

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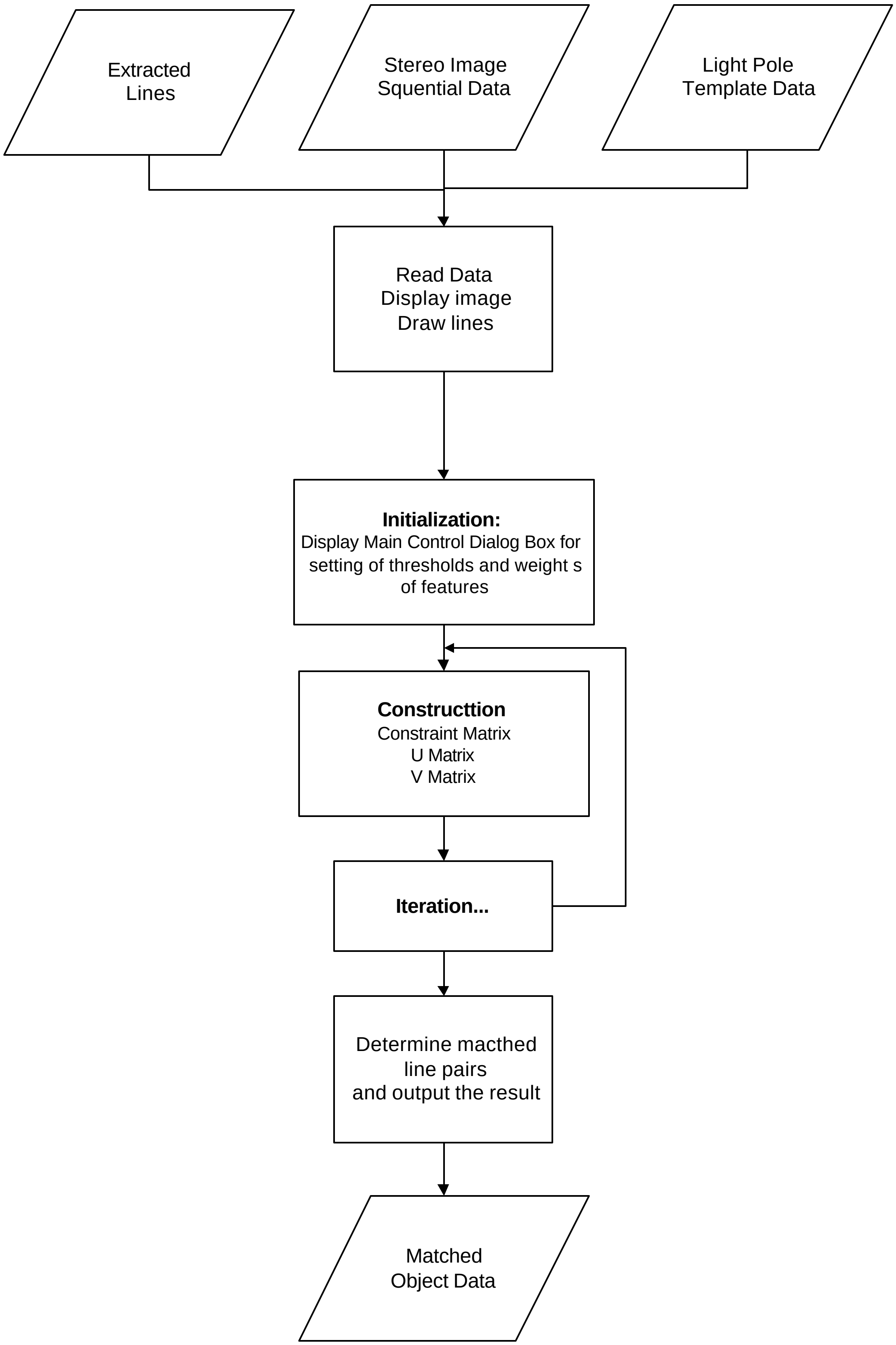
Appendix A. Program flowchart



Appendix B. Data Source

File Name : C:\MARINE\CHO
Number of Pair : 102
Number of Entities : 208
Type of Entity : Line
Point 1 : 278862.004,5047504.516,-0.667;418,250;350,215
Point 2 : 278861.697,5047505.150,-0.084;416,231;349,198
Code : 1020000
Type of Entity : Line
Point 1 : 278861.697,5047505.150,-0.084;416,231;349,198
Point 2 : 278861.391,5047504.804,-0.075;406,232;339,198
Code : 1020000
Type of Entity : Line
Point 1 : 278861.391,5047504.804,-0.075;406,232;339,198
Point 2 : 278861.452,5047504.710,-0.732;407,251;340,217
Code : 1020000
Type of Entity : Line
Point 1 : 278835.944,5047542.436,-0.049;312,211;275,178
Point 2 : 278834.197,5047545.319,6.135;309,142;272,110
Code : 1020000
Type of Entity : Line
Point 1 : 278834.075,5047544.856,6.178;306,142;269,110
Point 2 : 278835.572,5047542.422,-0.081;309,211;272,178
Code : 1020000
Type of Entity : Line
Point 1 : 278863.099,5047504.247,-0.535;442,246;372,213
Point 2 : 278862.714,5047504.709,6.145;433,42;362,11
Code : 1020000
Type of Entity : Line
Point 1 : 278862.649,5047504.553,6.168;430,42;359,11
Point 2 : 278862.951,5047503.975,-0.547;436,246;366,213
Code : 1020000
Type of Entity : Line
Point 1 : 278793.102,5047558.769,4.361;130,180;97,151
Point 2 : 278789.374,5047557.541,7.997;107,155;73,124
Code : 1020000
Type of Entity : Line
Point 1 : 278813.226,5047536.441,3.481;121,183;83,151
Point 2 : 278778.402,5047562.349,7.604;83,162;50,133
Code : 1020000
Type of Entity : Line
Point 1 : 278844.313,5047515.686,-0.251;231,227;183,196
Point 2 : 278863.834,5047487.770,-0.919;207,339;89,313
Code : 1020000
Type of Entity : Line
Point 1 : 278843.389,5047517.209,-0.290;233,227;186,195
Point 2 : 278863.899,5047487.950,-0.947;215,340;98,312
Code : 1020000
Type of Entity : Line
Point 1 : 278823.793,5047579.583,5.961;432,150;388,116
Point 2 : 278828.813,5047576.770,5.455;483,150;436,115
Code : 1080000
Type of Entity : Line
Point 1 : 278828.131,5047572.111,3.982;458,172;410,137
Point 2 : 278823.734,5047579.228,5.953;430,151;386,115
Code : 1080000
Type of Entity : Line
Point 1 : 278809.331,5047580.488,0.270;296,233;257,200
Point 2 : 278809.532,5047579.803,6.681;292,156;252,122
Code : 1082000
Type of Entity : Line
Point 1 : 278809.303,5047579.808,6.822;290,154;250,121
Point 2 : 278809.156,5047580.166,0.165;293,235;254,201
Code : 1082000
Type of Entity : Line
Point 1 : 278830.746,5047551.718,0.010;394,257;334,223
Point 2 : 278829.962,5047548.682,0.036;354,262;292,228
Code : 1080000
Type of Entity : Line
Point 1 : 278829.962,5047548.682,0.036;354,262;292,228
Point 2 : 278835.291,5047541.525,-0.120;413,285;334,251
Code : 1080000
Type of Entity : Line
Point 1 : 278820.865,5047559.133,-0.185;293,253;244,220
Point 2 : 278834.264,5047539.986,-0.193;366,293;286,259
Code : 1080000
Type of Entity : Line
Point 1 : 278834.553,5047544.968,-0.015;426,270;354,238
Point 2 : 278834.232,5047545.456,6.735;416,58;343,23
Code : 1080000
Type of Entity : Line
Point 1 : 278834.309,5047544.892,6.637;413,58;340,23
Point 2 : 278834.413,5047544.812,-0.002;421,270;349,238
Code : 1080000
Type of Entity : Line
Point 1 : 278803.515,5047584.385,-0.009;345,262;284,229
Point 2 : 278812.408,5047572.079,-0.082;442,313;345,279
Code : 1130000
Type of Entity : Line
Point 1 : 278803.137,5047585.015,-0.240;344,266;284,234
Point 2 : 278812.385,5047572.055,-0.216;441,319;344,286
Code : 1130000
Type of Entity : Line
Point 1 : 278798.978,5047581.088,-0.057;228,269;167,238
Point 2 : 278807.480,5047568.959,-0.008;215,319;120,290
Code : 1130000
Type of Entity : Line
Point 1 : 278798.841,5047581.036,-0.013;225,268;164,237
Point 2 : 278807.332,5047568.895,-0.004;209,319;114,290
Code : 1130000
Type of Entity : Line
Point 1 : 278808.156,5047582.962,0.204;429,259;361,225
Point 2 : 278808.067,5047582.777,6.728;422,70;352,36
Code : 1130000
Type of Entity : Line
Point 1 : 278807.800,5047583.351,0.175;425,259;358,225
Point 2 : 278807.730,5047583.227,6.840;418,69;348,36
Code : 1130000
Type of Entity : Line
Point 1 : 278801.248,5047606.832,3.292;451,181;403,146
Point 2 : 278799.853,5047608.099,4.590;437,162;391,128
Code : 1130000
Type of Entity : Line
Point 1 : 278802.051,5047605.068,3.396;454,178;405,144
Point 2 : 278799.882,5047608.260,4.846;438,158;392,124
Code : 1130000
Type of Entity : Line
Point 1 : 278786.310,5047613.079,5.825;316,159;275,126
Point 2 : 278784.302,5047616.635,-0.599;318,238;279,205
Code : 1130000
Type of Entity : Line
Point 1 : 278784.582,5047615.599,5.958;313,159;273,126
Point 2 : 278782.114,5047619.715,-0.694;314,238;276,204
Code : 1130000
Type of Entity : Line
Point 1 : 278805.387,5047585.497,0.578;390,245;329,211
Point 2 : 278804.795,5047586.964,-0.121;391,260;332,226
Code : 1130000
Type of Entity : Line
Point 1 : 278805.062,5047585.088,0.551;380,246;319,213
Point 2 : 278805.143,5047584.972,-0.002;381,261;320,227
Code : 1130000
Type of Entity : Line
Point 1 : 278767.878,5047638.701,4.884;290,183;256,150
Point 2 : 278761.721,5047648.713,-1.530;291,234;259,201

Code : 1131000
Type of Entity : Line
Point 1 : 278767.514,5047638.761,5.079;288,181;254,148
Point 2 : 278761.379,5047648.352,-1.503;288,234;256,201
Code : 1132000
Type of Entity : Line
Point 1 : 278812.502,5047561.813,-0.019;189,428;16,401
Point 2 : 278808.097,5047568.073,-0.008;213,327;113,298
Code : 1130000
Type of Entity : Line
Point 1 : 278807.952,5047568.021,0.004;207,326;106,297
Point 2 : 278812.303,5047561.843,-0.047;179,427;8,401
Code : 1130000
Type of Entity : Line
Point 1 : 278761.086,5047619.774,1.183;167,222;132,191
Point 2 : 278772.008,5047604.035,1.359;144,224;104,194
Code : 1130000
Type of Entity : Line
Point 1 : 278748.351,5047634.092,-0.390;167,233;135,201
Point 2 : 278769.669,5047605.888,0.548;140,234;100,203
Code : 1130000
Type of Entity : Line
Point 1 : 278780.338,5047617.411,-0.963;289,242;251,210
Point 2 : 278803.807,5047583.588,-0.097;343,266;281,233
Code : 1130000
Type of Entity : Line
Point 1 : 278801.868,5047607.478,3.032;461,185;413,150
Point 2 : 278802.447,5047605.509,2.025;461,201;412,166
Code : 1130000
Type of Entity : Line
Point 1 : 278802.447,5047605.509,2.025;461,201;412,166
Point 2 : 278803.159,5047606.743,2.022;476,200;427,165
Code : 1130000
Type of Entity : Line
Point 1 : 278803.159,5047606.743,2.022;476,200;427,165
Point 2 : 278802.446,5047608.980,3.086;475,183;427,148
Code : 1130000
Type of Entity : Line
Point 1 : 278802.446,5047608.980,3.086;475,183;427,148
Point 2 : 278801.772,5047607.535,3.006;460,185;412,150
Code : 1130000
Type of Entity : Line
Point 1 : 278805.103,5047602.439,3.282;487,177;435,142
Point 2 : 278801.432,5047606.987,3.339;454,180;406,145
Code : 1130000
Type of Entity : Line
Point 1 : 278791.911,5047618.358,2.599;393,196;353,162
Point 2 : 278791.577,5047618.472,3.496;390,185;349,151
Code : 1130000
Type of Entity : Line
Point 1 : 278791.577,5047618.472,3.496;390,185;349,151
Point 2 : 278789.652,5047627.749,3.678;408,184;368,149
Code : 1130000
Type of Entity : Line
Point 1 : 278789.652,5047627.749,3.678;408,184;368,149
Point 2 : 278792.130,5047626.963,5.943;426,157;387,122
Code : 1130000
Type of Entity : Line
Point 1 : 278792.130,5047626.963,5.943;426,157;387,122
Point 2 : 278787.526,5047633.111,7.393;407,146;368,112
Code : 1130000
Type of Entity : Line
Point 1 : 278787.526,5047633.111,7.393;407,146;368,112
Point 2 : 278787.050,5047622.492,2.946;366,194;327,160
Code : 1130000
Type of Entity : Line
Point 1 : 278797.109,5047576.718,1.497;133,236;67,207
Point 2 : 278795.889,5047576.420,1.555;109,236;42,207
Code : 1130000
Type of Entity : Line
Point 1 : 278795.889,5047576.420,1.555;109,236;42,207
Point 2 : 278796.573,5047574.966,1.472;94,240;24,211
Code : 1130000
Type of Entity : Line
Point 1 : 278798.514,5047574.924,1.395;128,242;56,212
Point 2 : 278796.641,5047577.196,1.460;133,237;68,207
Code : 1130000
Type of Entity : Line
Point 1 : 278796.641,5047577.196,1.460;133,237;68,207
Point 2 : 278797.625,5047576.614,0.632;141,261;75,231
Code : 1130000
Type of Entity : Line
Point 1 : 278797.625,5047576.614,0.632;141,261;75,231
Point 2 : 278798.460,5047574.558,0.133;122,281;50,252
Code : 1130000
Type of Entity : Line
Point 1 : 278798.751,5047574.239,0.506;121,270;48,241
Point 2 : 278798.026,5047574.929,0.073;121,281;50,252
Code : 1130000
Type of Entity : Line
Point 1 : 278798.026,5047574.929,0.073;121,281;50,252
Point 2 : 278796.635,5047574.061,0.018;81,285;10,256
Code : 1130000
Type of Entity : Line
Point 1 : 278796.635,5047574.061,0.018;81,285;10,256
Point 2 : 278796.529,5047574.131,0.427;80,272;9,244
Code : 1130000
Type of Entity : Line
Point 1 : 278796.970,5047573.794,0.478;80,272;9,244
Point 2 : 278796.599,5047574.940,1.423;94,241;24,213
Code : 1130000
Type of Entity : Line
Point 1 : 278796.599,5047574.940,1.423;94,241;24,213
Point 2 : 278798.500,5047574.880,1.416;127,241;55,212
Code : 1130000
Type of Entity : Line
Point 1 : 278798.500,5047574.880,1.416;127,241;55,212
Point 2 : 278798.319,5047574.608,0.454;120,271;49,242
Code : 1130000
Type of Entity : Line
Point 1 : 278798.319,5047574.608,0.454;120,271;49,242
Point 2 : 278796.616,5047574.100,0.399;80,273;10,245
Code : 1130000
Type of Entity : Line
Point 1 : 278798.468,5047593.777,-0.043;340,248;289,215
Point 2 : 278807.006,5047581.509,0.171;389,264;322,230
Code : 1130000
Type of Entity : Line
Point 1 : 278807.006,5047581.509,0.171;389,264;322,230
Point 2 : 278811.508,5047576.076,-0.066;458,291;372,257
Code : 1130000
Type of Entity : Line
Point 1 : 278811.508,5047576.076,-0.066;458,291;372,257
Point 2 : 278811.749,5047578.407,-0.152;488,285;407,250
Code : 1130000
Type of Entity : Line
Point 1 : 278759.708,5047615.795,7.298;135,163;97,131
Point 2 : 278762.223,5047613.030,2.908;135,207;97,176
Code : 1130000
Type of Entity : Line
Point 1 : 278759.279,5047615.912,7.524;133,161;95,130
Point 2 : 278761.709,5047613.076,3.021;132,206;94,175
Code : 1130000
Type of Entity : Line
Point 1 : 278775.918,5047627.393,1.209;316,210;273,177
Point 2 : 278777.582,5047624.523,-0.752;318,240;274,208
Code : 1160000
Type of Entity : Line
Point 1 : 278760.972,5047650.311,5.109;297,167;261,135
Point 2 : 278762.718,5047647.560,-1.366;300,232;264,199

Code : 1160000
Type of Entity : Line
Point 1 : 278760.745,5047650.211,5.223;295,166;259,134
Point 2 : 278762.451,5047647.297,-1.347;297,232;261,199
Code : 1160000
Del-Type of Entity : Line
Point 1 : 278782.983,5047619.351,-0.615;351,244;303,210
Point 2 : 278783.536,5047618.153,5.853;348,129;298,95
Code : 1160000
Type of Entity : Line
Point 1 : 278783.380,5047618.017,5.888;345,128;295,95
Point 2 : 278783.578,5047617.647,-0.524;348,244;299,211
Code : 1160000
Type of Entity : Line
Point 1 : 278756.104,5047618.797,6.795;76,145;31,113
Point 2 : 278757.667,5047617.169,-0.987;79,251;35,222
Code : 1160000
Type of Entity : Line
Point 1 : 278758.532,5047616.933,6.513;79,145;33,115
Point 2 : 278758.123,5047617.209,-0.990;83,251;39,222
Code : 1160000
Type of Entity : Line
Point 1 : 278784.295,5047602.358,-0.465;224,269;164,238
Point 2 : 278798.054,5047582.751,-0.101;191,420;25,395
Code : 1160000
Type of Entity : Line
Point 1 : 278784.637,5047601.655,-0.334;221,267;160,237
Point 2 : 278797.974,5047582.655,-0.090;182,421;15,395
Code : 1160000
Type of Entity : Line
Point 1 : 278786.913,5047608.506,-0.795;330,264;274,232
Point 2 : 278796.256,5047595.304,-0.433;405,302;320,269
Code : 1160000
Type of Entity : Line
Point 1 : 278779.956,5047618.665,-0.983;342,263;281,230
Point 2 : 278788.417,5047606.911,-0.788;435,315;340,282
Code : 1180000
Type of Entity : Line
Point 1 : 278774.106,5047616.784,-0.760;220,259;161,227
Point 2 : 278782.841,5047604.191,-0.583;205,309;114,280
Code : 1180000
Type of Entity : Line
Point 1 : 278774.814,5047616.155,-0.728;224,259;164,229
Point 2 : 278783.502,5047603.687,-0.487;213,310;119,280
Code : 1180000
Type of Entity : Line
Point 1 : 278783.045,5047619.113,6.005;406,74;340,39
Point 2 : 278782.909,5047619.730,-0.669;410,253;347,221
Code : 1180000
Type of Entity : Line
Point 1 : 278776.958,5047625.689,1.217;348,201;294,169
Point 2 : 278777.247,5047625.237,-0.877;350,246;296,213
Code : 1180000
Type of Entity : Line
Point 1 : 278782.939,5047619.027,5.992;403,74;337,40
Point 2 : 278782.759,5047619.615,-0.679;406,254;343,221
Code : 1180000

Type of Entity : Line
Point 1 : 278790.329,5047554.158,6.325;87,172;52,144
Point 2 : 278782.861,5047563.017,8.544;96,160;62,130
Code : 1030000
Type of Entity : Line
Point 1 : 278782.861,5047563.017,8.544;96,160;62,130
Point 2 : 278791.552,5047559.890,4.296;122,189;88,159
Code : 1030000
Type of Entity : Line
Point 1 : 278835.589,5047542.427,6.477;318,138;278,106
Point 2 : 278835.710,5047542.340,0.055;321,218;282,187
Code : 1030000
Type of Entity : Line
Point 1 : 278835.470,5047542.044,6.433;315,138;275,106
Point 2 : 278837.272,5047539.001,0.291;318,218;279,187
Code : 1030000
Type of Entity : Line
Point 1 : 278862.042,5047504.202,-0.656;495,278;406,244
Point 2 : 278861.835,5047504.836,-0.059;493,250;406,219
Code : 1030000
Type of Entity : Line
Point 1 : 278861.835,5047504.836,-0.059;493,250;406,219
Point 2 : 278862.338,5047503.198,-0.293;492,254;407,245
Code : 1030000
Type of Entity : Line
Point 1 : 278862.338,5047503.198,-0.293;492,254;407,245
Point 2 : 278861.371,5047504.800,-0.127;477,254;391,221
Code : 1030000
Type of Entity : Line
Point 1 : 278861.371,5047504.800,-0.127;477,254;391,221
Point 2 : 278861.618,5047504.086,-0.722;479,280;391,248
Code : 1030000
Type of Entity : Line
Point 1 : 278859.130,5047507.335,-0.799;434,271;358,238
Point 2 : 278862.448,5047503.036,-0.961;499,296;406,263
Code : 1030000
Type of Entity : Line
Point 1 : 278862.448,5047503.036,-0.961;499,296;406,263
Point 2 : 278861.629,5047501.110,-0.897;446,303;350,269
Code : 1030000
Type of Entity : Line
Point 1 : 278843.097,5047517.692,-0.361;218,260;158,230
Point 2 : 278857.290,5047497.524,-0.825;190,435;14,410
Code : 1040000
Type of Entity : Line
Point 1 : 278844.351,5047515.820,-0.232;216,260;153,230
Point 2 : 278857.152,5047497.470,-0.835;179,436;3,411
Code : 1040000
Type of Entity : Line
Point 1 : 278789.568,5047555.214,6.565;60,175;23,146
Point 2 : 278790.028,5047556.640,8.122;70,162;33,131
Code : 1040000
Type of Entity : Line
Point 1 : 278790.028,5047556.640,8.122;70,162;33,131
Point 2 : 278789.105,5047562.294,4.345;97,195;62,166
Code : 1040000
Type of Entity : Line
Point 1 : 278834.649,5047544.659,6.616;317,138;274,106
Point 2 : 278834.570,5047544.921,-0.056;320,232;278,198
Code : 1040000
Type of Entity : Line
Point 1 : 278834.379,5047544.602,6.600;314,138;271,106
Point 2 : 278836.798,5047540.291,0.048;317,232;275,198
Code : 1040000
Type of Entity : Line
Point 1 : 278851.081,5047524.408,-0.357;424,250;364,215
Point 2 : 278849.829,5047520.611,-0.290;370,254;308,220
Code : 1040000
Type of Entity : Line
Point 1 : 278849.829,5047520.611,-0.290;370,254;308,220
Point 2 : 278854.922,5047513.713,-0.561;428,277;350,244
Code : 1040000
Type of Entity : Line
Point 1 : 278847.869,5047520.606,-0.476;371,278;295,246
Point 2 : 278842.726,5047518.299,-0.334;214,278;140,248
Code : 1050000
Type of Entity : Line
Point 1 : 278842.987,5047517.946,-0.314;214,279;139,248
Point 2 : 278850.911,5047506.490,-0.626;189,391;39,364
Code : 1050000
Type of Entity : Line

Point 1 : 278842.520,5047518.208,-0.357;208,280;134,248
Point 2 : 278850.875,5047506.316,-0.616;180,393;28,366
Code : 1050000
Type of Entity : Line
Point 1 : 278834.331,5047545.112,6.517;331,129;285,95
Point 2 : 278834.561,5047544.870,-0.099;336,235;290,203
Code : 1050000
Type of Entity : Line
Point 1 : 278834.162,5047544.947,6.492;328,129;282,95
Point 2 : 278835.241,5047543.002,-0.026;333,235;287,203
Code : 1050000
Type of Entity : Line
Point 1 : 278793.595,5047558.160,4.243;83,193;45,163
Point 2 : 278785.754,5047560.568,8.431;53,157;15,127
Code : 1050000
Type of Entity : Line
Point 1 : 278785.754,5047560.568,8.431;53,157;15,127
Point 2 : 278783.990,5047559.827,6.808;40,173;2,143
Code : 1050000
Type of Entity : Line
Point 1 : 278848.064,5047520.239,-0.441;372,278;295,246
Point 2 : 278852.804,5047513.724,-0.689;454,326;346,292
Code : 1050000
Type of Entity : Line
Point 1 : 278852.804,5047513.724,-0.689;454,326;346,292
Point 2 : 278852.751,5047513.919,-0.540;454,316;347,283
Code : 1050000
Type of Entity : Line
Point 1 : 278830.087,5047536.195,-0.138;219,260;164,228
Point 2 : 278840.986,5047520.784,-0.259;207,306;117,276
Code : 1060000
Type of Entity : Line
Point 1 : 278825.690,5047573.954,5.562;396,163;356,129
Point 2 : 278829.544,5047568.829,3.883;415,179;373,145
Code : 1060000
Type of Entity : Line
Point 1 : 278834.810,5047544.369,6.626;355,112;303,81
Point 2 : 278834.389,5047545.520,-0.054;361,244;310,212
Code : 1060000
Type of Entity : Line
Point 1 : 278834.549,5047544.487,6.665;351,112;299,81
Point 2 : 278834.827,5047544.132,0.014;357,244;306,212
Code : 1060000
Type of Entity : Line
Point 1 : 278830.253,5047536.250,-0.168;222,260;167,229
Point 2 : 278840.957,5047521.056,-0.293;212,306;123,276
Code : 1060000
Type of Entity : Line
Point 1 : 278846.634,5047525.872,-0.290;463,288;375,254
Point 2 : 278843.173,5047530.613,-0.212;408,270;336,236
Code : 1060000
Type of Entity : Line
Point 1 : 278846.844,5047525.269,-0.253;464,288;374,256
Point 2 : 278845.776,5047524.112,-0.294;413,295;323,262
Code : 1060000
Type of Entity : Line
Point 1 : 278845.776,5047524.112,-0.294;413,295;323,262
Point 2 : 278847.749,5047521.486,-0.408;455,316;350,284
Code : 1060000
Type of Entity : Line
Point 1 : 278812.306,5047575.425,6.075;292,170;253,137
Point 2 : 278809.738,5047579.935,0.223;294,236;257,204
Code : 1071000
Type of Entity : Line
Point 1 : 278807.779,5047582.479,6.625;288,169;251,137
Point 2 : 278809.492,5047579.673,0.149;291,237;254,205
Code : 1072000
Type of Entity : Line
Point 1 : 278826.182,5047572.750,5.452;411,165;368,129
Point 2 : 278826.358,5047577.558,4.241;431,181;389,147
Code : 1070000
Type of Entity : Line
Point 1 : 278834.668,5047544.684,6.518;377,101;317,66
Point 2 : 278834.571,5047545.120,-0.024;385,260;326,228
Code : 1070000
Type of Entity : Line
Point 1 : 278834.169,5047545.373,6.642;374,101;314,66
Point 2 : 278834.822,5047544.130,0.017;381,260;322,228
Code : 1070000
Type of Entity : Line
Point 1 : 278837.336,5047538.238,-0.007;382,271;313,240
Point 2 : 278842.504,5047531.347,-0.155;464,301;371,268
Code : 1070000
Type of Entity : Line
Point 1 : 278830.612,5047535.755,-0.100;211,280;145,250
Point 2 : 278840.819,5047521.164,-0.311;184,389;43,362
Code : 1070000
Type of Entity : Line
Point 1 : 278830.068,5047536.194,-0.138;207,280;142,250
Point 2 : 278840.731,5047521.036,-0.317;175,391;33,364
Code : 1070000
Type of Entity : Line
Point 1 : 278826.936,5047551.170,-0.232;346,276;276,244
Point 2 : 278833.924,5047541.488,-0.368;451,337;339,306
Code : 1090000
Type of Entity : Line
Point 1 : 278822.348,5047560.477,-0.028;342,250;286,220
Point 2 : 278827.491,5047553.241,-0.107;380,267;312,234
Code : 1090000
Type of Entity : Line
Point 1 : 278816.282,5047556.732,0.097;211,255;155,225
Point 2 : 278829.323,5047537.963,-0.180;181,346;66,317
Code : 1090000
Type of Entity : Line
Point 1 : 278816.639,5047555.890,0.135;207,256;150,225
Point 2 : 278829.156,5047537.902,-0.177;173,346;58,317
Code : 1090000
Type of Entity : Line
Point 1 : 278808.469,5047582.397,6.815;305,141;263,110
Point 2 : 278809.835,5047580.079,0.235;309,230;267,199
Code : 1091000
Type of Entity : Line
Point 1 : 278809.456,5047580.177,6.575;303,143;260,110
Point 2 : 278809.431,5047580.250,0.165;306,232;264,199
Code : 1092000
Type of Entity : Line
Point 1 : 278820.700,5047559.870,-0.167;340,271;274,237
Point 2 : 278815.341,5047557.942,-0.034;212,270;148,241
Code : 1100000
Type of Entity : Line
Point 1 : 278814.596,5047571.212,0.097;332,245;280,212
Point 2 : 278819.138,5047565.422,-0.170;361,259;302,225
Code : 1100000
Type of Entity : Line
Point 1 : 278808.842,5047581.624,6.803;323,132;277,97
Point 2 : 278808.968,5047581.655,0.230;328,234;283,201
Code : 1100000
Type of Entity : Line
Point 1 : 278808.597,5047581.588,6.856;320,131;274,97
Point 2 : 278808.853,5047581.372,0.216;325,234;280,202
Code : 1100000
Type of Entity : Line
Point 1 : 278814.763,5047575.686,1.677;364,212;314,176
Point 2 : 278814.782,5047575.536,0.598;364,231;314,197
Code : 1100000
Type of Entity : Line
Point 1 : 278765.547,5047589.868,6.017;40,180;1,152
Point 2 : 278772.621,5047586.637,5.621;59,180;19,152
Code : 1100000
Type of Entity : Line

Point 1 : 278772.621,5047586.637,5.621;59,180;19,152
Point 2 : 278775.953,5047583.424,3.193;58,207;17,177
Code : 1100000
Type of Entity : Line
Point 1 : 278821.277,5047567.981,0.414;420,239;361,207
Point 2 : 278821.488,5047567.362,1.546;419,213;359,180
Code : 1100000
Type of Entity : Line
Point 1 : 278821.488,5047567.362,1.546;419,213;359,180
Point 2 : 278821.123,5047566.959,1.637;409,212;349,178
Code : 1100000
Type of Entity : Line
Point 1 : 278821.123,5047566.959,1.637;409,212;349,178
Point 2 : 278821.517,5047565.944,0.591;410,239;349,204
Code : 1100000
Type of Entity : Line
Point 1 : 278822.718,5047559.487,0.064;381,265;312,231
Point 2 : 278827.105,5047554.267,-0.290;450,295;364,263
Code : 1100000
Type of Entity : Line
Point 1 : 278820.768,5047559.918,-0.224;342,272;276,239
Point 2 : 278826.528,5047551.670,-0.207;399,304;308,272
Code : 1100000
Type of Entity : Line
Point 1 : 278815.277,5047557.758,-0.066;210,296;127,265
Point 2 : 278821.313,5047549.082,-0.168;178,392;31,364
Code : 1110000
Type of Entity : Line
Point 1 : 278815.361,5047557.452,-0.002;206,294;122,265
Point 2 : 278821.158,5047549.019,-0.193;168,393;21,367
Code : 1110000
Type of Entity : Line
Point 1 : 278814.609,5047576.739,0.633;412,233;355,197
Point 2 : 278814.070,5047577.918,1.552;410,211;354,177
Code : 1110000
Type of Entity : Line
Point 1 : 278814.070,5047577.918,1.552;410,211;354,177
Point 2 : 278813.297,5047578.392,1.566;400,210;345,178
Code : 1110000
Type of Entity : Line
Point 1 : 278813.297,5047578.392,1.566;400,210;345,178
Point 2 : 278813.789,5047577.218,0.490;401,235;345,201
Code : 1110000
Type of Entity : Line
Point 1 : 278807.942,5047583.281,0.081;353,238;304,205
Point 2 : 278808.371,5047582.139,6.753;348,116;297,81
Code : 1110000
Type of Entity : Line
Point 1 : 278808.196,5047582.049,6.739;345,116;294,82
Point 2 : 278808.442,5047581.647,0.114;349,239;299,206
Code : 1110000
Type of Entity : Line
Point 1 : 278808.442,5047581.647,0.114;349,239;299,206
Point 2 : 278814.736,5047570.423,0.115;365,254;303,220
Code : 1110000
Type of Entity : Line
Point 1 : 278814.736,5047570.423,0.115;365,254;303,220
Point 2 : 278819.474,5047564.260,-0.078;415,275;339,241
Code : 1110000
Type of Entity : Line
Point 1 : 278818.008,5047563.869,-0.306;372,283;298,250
Point 2 : 278820.276,5047560.400,-0.255;394,296;309,264
Code : 1110000
Type of Entity : Line
Point 1 : 278805.867,5047571.473,-0.004;227,274;162,243
Point 2 : 278813.454,5047560.649,-0.003;212,326;110,297
Code : 1120000
Type of Entity : Line
Point 1 : 278806.421,5047570.379,0.015;222,277;155,245
Point 2 : 278813.170,5047560.735,-0.017;205,326;104,296
Code : 1120000
Type of Entity : Line
Point 1 : 278803.111,5047600.667,4.555;414,165;368,131
Point 2 : 278801.922,5047605.479,3.333;422,184;378,151
Code : 1120000
Type of Entity : Line
Point 1 : 278807.863,5047583.465,7.061;379,95;322,63
Point 2 : 278808.261,5047582.990,0.103;386,249;330,217
Code : 1120000
Type of Entity : Line
Point 1 : 278808.143,5047582.446,7.097;376,92;318,59
Point 2 : 278808.499,5047581.919,0.194;382,249;325,216
Code : 1120000
Type of Entity : Line
Point 1 : 278814.098,5047578.572,0.498;469,246;403,211
Point 2 : 278814.257,5047578.015,1.536;468,218;401,183
Code : 1120000
Type of Entity : Line
Point 1 : 278814.257,5047578.015,1.536;468,218;401,183
Point 2 : 278813.869,5047577.485,1.569;455,218;388,183
Code : 1120000
Type of Entity : Line
Point 1 : 278813.869,5047577.485,1.569;455,218;388,183
Point 2 : 278813.929,5047577.338,0.524;456,248;389,212
Code : 1120000
Type of Entity : Line
Point 1 : 278804.358,5047583.413,-0.316;327,258;274,226
Point 2 : 278810.424,5047574.769,-0.210;356,273;291,240
Code : 1120000
Type of Entity : Line
Point 1 : 278812.889,5047571.111,-0.112;373,281;300,248
Point 2 : 278818.354,5047563.599,-0.241;455,329;350,296
Code : 1120000
Type of Entity : Line
Point 1 : 278787.422,5047633.947,7.569;423,136;383,100
Point 2 : 278788.110,5047634.994,6.106;433,152;393,117
Code : 1140000
Type of Entity : Line
Point 1 : 278788.110,5047634.994,6.106;433,152;393,117
Point 2 : 278785.641,5047635.556,4.042;413,177;374,142
Code : 1140000
Type of Entity : Line
Point 1 : 278791.685,5047591.636,-0.218;226,262;170,231
Point 2 : 278798.172,5047582.431,-0.072;221,283;149,253
Code : 1140000
Type of Entity : Line
Point 1 : 278791.525,5047591.580,-0.192;223,262;167,230
Point 2 : 278798.314,5047581.992,-0.023;217,283;144,253
Code : 1140000
Type of Entity : Line
Point 1 : 278755.992,5047619.538,7.270;117,156;78,125
Point 2 : 278759.210,5047616.242,1.255;119,221;80,189
Code : 1140000
Type of Entity : Line
Point 1 : 278761.553,5047613.673,6.792;115,156;74,125
Point 2 : 278761.468,5047613.540,1.278;116,221;76,190
Code : 1140000
Type of Entity : Line
Point 1 : 278783.577,5047618.044,6.142;321,149;279,116
Point 2 : 278783.487,5047618.195,-0.650;323,239;282,206
Code : 1140000
Type of Entity : Line
Point 1 : 278783.440,5047617.726,6.180;318,148;276,116
Point 2 : 278784.648,5047615.457,-0.498;320,239;278,206
Code : 1140000
Type of Entity : Line
Point 1 : 278804.907,5047586.833,0.518;436,255;362,222
Point 2 : 278804.781,5047585.938,0.525;424,256;349,225
Code : 1140000
Type of Entity : Line

Point 1 : 278804.781,5047585.938,0.525;424,256;349,225
Point 2 : 278804.983,5047585.536,0.015;426,276;350,242
Code : 1140000
Type of Entity : Line
Point 1 : 278795.913,5047595.768,-0.510;331,262;276,230
Point 2 : 278803.327,5047584.892,-0.190;375,283;301,251
Code : 1140000
Type of Entity : Line
Point 1 : 278798.390,5047582.007,-0.129;219,287;146,256
Point 2 : 278807.353,5047569.367,-0.004;193,410;33,383
Code : 1140000
Type of Entity : Line
Point 1 : 278798.830,5047581.242,-0.050;216,287;141,257
Point 2 : 278807.244,5047569.253,-0.004;182,411;21,385
Code : 1140000
Type of Entity : Line
Point 1 : 278807.979,5047583.533,6.208;496,34;408,2
Point 2 : 278808.032,5047583.848,0.150;504,280;418,244
Code : 1140000
Type of Entity : Line
Point 1 : 278807.929,5047583.157,6.187;491,34;402,0
Point 2 : 278807.848,5047583.644,0.129;496,281;410,246
Code : 1140000
Type of Entity : Line
Point 1 : 278785.331,5047638.190,4.503;439,168;398,132
Point 2 : 278787.387,5047637.808,6.399;458,142;416,108
Code : 1150000
Type of Entity : Line
Point 1 : 278787.387,5047637.808,6.399;458,142;416,108
Point 2 : 278786.479,5047636.705,7.644;445,127;403,93
Code : 1150000
Type of Entity : Line
Point 1 : 278786.479,5047636.705,7.644;445,127;403,93
Point 2 : 278791.164,5047630.350,5.994;475,141;430,105
Code : 1150000
Type of Entity : Line
Point 1 : 278791.164,5047630.350,5.994;475,141;430,105
Point 2 : 278786.988,5047635.558,3.818;447,175;405,139
Code : 1150000
Type of Entity : Line
Point 1 : 278758.873,5047616.615,-0.861;104,248;63,219
Point 2 : 278758.037,5047617.362,6.146;100,161;58,132
Code : 1150000
Type of Entity : Line
Point 1 : 278757.341,5047617.616,6.149;97,162;55,132
Point 2 : 278760.547,5047614.493,-0.752;100,249;58,219
Code : 1150000
Type of Entity : Line
Point 1 : 278791.137,5047592.467,-0.281;222,278;157,248
Point 2 : 278798.140,5047582.533,-0.080;212,322;115,292
Code : 1150000
Type of Entity : Line
Point 1 : 278791.390,5047591.913,-0.221;219,278;153,248
Point 2 : 278798.152,5047582.309,-0.046;207,322;109,292
Code : 1150000
Type of Entity : Line
Point 1 : 278783.222,5047618.728,6.136;332,142;287,107
Point 2 : 278783.265,5047618.735,-0.629;335,243;291,210
Code : 1150000
Type of Entity : Line
Point 1 : 278784.073,5047616.712,5.906;330,143;284,109
Point 2 : 278783.024,5047618.496,-0.645;331,244;287,210
Code : 1150000
Type of Entity : Line
Point 1 : 278797.372,5047593.292,-0.167;362,277;292,243
Point 2 : 278803.183,5047585.427,-0.092;444,315;344,282
Code : 1150000
Type of Entity : Line
Point 1 : 278783.426,5047603.324,-0.456;215,283;144,252
Point 2 : 278790.187,5047593.764,-0.248;200,343;87,313
Code : 1170000
Type of Entity : Line
Point 1 : 278759.054,5047653.628,5.488;302,157;265,125
Point 2 : 278760.999,5047650.409,-1.376;305,231;268,196
Code : 1170000
Type of Entity : Line
Point 1 : 278761.019,5047649.678,5.284;300,158;262,125
Point 2 : 278760.574,5047650.455,-1.420;302,231;265,197
Code : 1170000
Type of Entity : Line
Point 1 : 278784.078,5047617.021,5.808;372,107;314,73
Point 2 : 278783.498,5047618.485,-0.513;376,248;321,214
Code : 1170000
Type of Entity : Line
Point 1 : 278783.489,5047617.830,5.912;368,107;311,73
Point 2 : 278783.309,5047618.228,-0.516;371,248;316,215
Code : 1170000
Type of Entity : Line
Point 1 : 278788.826,5047605.823,-0.626;372,284;299,251
Point 2 : 278795.301,5047596.892,-0.500;487,346;371,313
Code : 1170000
Type of Entity : Line
Point 1 : 278783.301,5047603.819,-0.469;220,282;150,250
Point 2 : 278790.331,5047593.821,-0.267;207,343;94,315
Code : 1170000
Type of Entity : Line
Point 1 : 278838.701,5047548.128,8.199;479,55;417,20
Point 2 : 278837.991,5047549.632,6.210;474,109;414,74
Code : 1070000
Type of Entity : Line
Point 1 : 278839.467,5047546.610,7.838;487,56;423,21
Point 2 : 278838.356,5047549.884,5.158;483,133;423,98
Code : 1070000
Type of Entity : Line
Point 1 : 278838.356,5047549.884,5.158;483,133;423,98
Point 2 : 278838.393,5047549.469,2.631;483,192;423,156
Code : 1070000
Type of Entity : Line
Point 1 : 278838.155,5047548.369,5.068;471,133;410,99
Point 2 : 278838.019,5047548.970,2.546;473,194;413,159
Code : 1070000
Type of Entity : Line
Point 1 : 278827.334,5047566.582,3.971;467,155;410,122
Point 2 : 278827.990,5047564.070,2.055;467,198;408,162
Code : 1090000
Type of Entity : Line
Point 1 : 278827.599,5047563.970,3.889;458,155;399,122
Point 2 : 278827.457,5047564.644,1.962;460,201;402,164
Code : 1090000

Appendix C **Results**

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******** CHO_102_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 102
Image Sequence         : 0
Number of Entities     : 4
1020003;-1;312,211;309,142~32;278833.6638,5047546.5245,-0.1878;278832.0524,5047549.1722,6.4489
               1021003,1,278833.6638,5047546.5245,-0.1878
               1030086,0,278826.2356,5047559.8504,-0.3537
               1031086,1,278840.0621,5047535.0211,0.1100
1020004;1;309,211;306,142~32;278833.4115,5047546.2667,-0.1697;278831.7704,5047548.9436,6.4643
               1021004,1,278833.4115,5047546.2667,-0.1697
               1030087,0,278827.3884,5047556.9579,-0.2786
               1031087,1,278838.8174,5047536.6458,0.0821
1020005;-1;442,246;433,42~12;278863.1070,5047504.2235,-0.5496;278862.7249,5047504.6827,6.1560
               1021005,1,278863.1070,5047504.2235,-0.5496
1020006;1;436,246;430,42~12;278862.9378,5047504.0117,-0.5327;278862.6330,5047504.5941,6.1590
               1021006,1,278862.9378,5047504.0117,-0.5327
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******** CHO_102_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 102
Image Sequence         : 1
Number of Entities     : 6
1021002;-1;340,217;339,198~1;278745.8099,5047749.9403,-19.8457;278745.8099,5047749.9403,-13.0507
1021000;1;350,215;349,198~1;278734.8064,5047784.5799,-21.7981;278734.8064,5047784.5799,-15.0031
1021003;-1;275,178;272,110~32;278833.6638,5047546.5245,-0.1878;278832.0524,5047549.1722,6.4489
               1020003,0,278833.6638,5047546.5245,-0.1878
               1031086,1,278820.3410,5047569.1336,-0.6939
               1030086,0,278830.9636,5047551.0996,-0.1715
1021004;1;272,178;269,110~32;278833.4115,5047546.2667,-0.1697;278831.7704,5047548.9436,6.4643
               1020004,0,278833.4115,5047546.2667,-0.1697
               1031087,1,278822.0402,5047565.3729,-0.5887
               1030087,0,278831.1730,5047550.0211,-0.1351
1021005;-1;372,213;362,11~12;278863.1070,5047504.2235,-0.5496;278862.7249,5047504.6827,6.1560
               1020005,0,278863.1070,5047504.2235,-0.5496
1021006;1;366,213;359,11~12;278862.9378,5047504.0117,-0.5327;278862.6330,5047504.5941,6.1590
               1020006,0,278862.9378,5047504.0117,-0.5327
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******** CHO_103_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 103
Image Sequence         : 0
Number of Entities     : 2
1030086;-1;321,218;318,138~52;278834.0761,5047545.3596,-0.0149;278834.0607,5047545.2470,6.6768
               1031086,1,278834.0761,5047545.3596,-0.0149
               1020003,0,278826.2356,5047559.8504,-0.3537
               1021003,1,278830.9636,5047551.0996,-0.1715
               1040098,0,278842.4271,5047529.8777,0.3627
               1041098,1,278829.7600,5047553.3932,-0.1949
1030087;1;318,218;315,138~52;278833.8439,5047545.1470,0.0012;278833.8246,5047545.0466,6.6897
               1031087,1,278833.8439,5047545.1470,0.0012
               1020004,0,278827.3884,5047556.9579,-0.2786
               1021004,1,278831.1730,5047550.0211,-0.1351
               1040099,0,278843.1933,5047528.0049,0.4153
               1041099,1,278828.5523,5047554.8858,-0.2206
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******** CHO_103_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 103
Image Sequence         : 1
Number of Entities     : 2
1031086;-1;282,187;278,106~52;278834.0761,5047545.3596,-0.0149;278834.0607,5047545.2470,6.6768
               1030086,0,278834.0761,5047545.3596,-0.0149
               1021003,1,278820.3410,5047569.1336,-0.6939
               1020003,0,278840.0621,5047535.0211,0.1100
               1041098,1,278841.8706,5047531.9172,0.2583
               1040098,0,278836.6650,5047540.8946,-0.0037
1031087;1;279,187;275,106~52;278833.8439,5047545.1470,0.0012;278833.8246,5047545.0466,6.6897
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              1030087,0,278833.8439,5047545.1470,0.0012
              1021004,1,278822.0402,5047565.3729,-0.5887
              1020004,0,278838.8174,5047536.6458,0.0821
              1041099,1,278843.1799,5047529.2017,0.3369
              1040099,0,278836.8722,5047539.9736,0.0292
============================
******** CHO_104_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 104
Image Sequence         : 0
Number of Entities     : 2
1040098;-1;320,232;317,138~52;278834.5748,5047544.9094,-0.0915;278834.6493,5047544.6592,6.6155
              1041098,1,278834.5748,5047544.9094,-0.0915
              1030086,0,278842.4271,5047529.8777,0.3627
              1031086,1,278836.6650,5047540.8946,-0.0037
              1050105,0,278835.1656,5047543.7887,-0.0570
              1051105,1,278833.5596,5047546.8717,-0.1963
1040099;1;317,232;314,138~52;278834.3798,5047544.7102,-0.0785;278834.4395,5047544.4931,6.6252
              1041099,1,278834.3798,5047544.7102,-0.0785
              1030087,0,278843.1933,5047528.0049,0.4153
              1031087,1,278836.8722,5047539.9736,0.0292
              1050106,0,278835.7148,5047542.1895,-0.0010
              1051106,1,278832.2551,5047548.7652,-0.2522
============================
******** CHO_104_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 104
Image Sequence         : 1
Number of Entities     : 2
1041098;-1;278,198;274,106~52;278834.5748,5047544.9094,-0.0915;278834.6493,5047544.6592,6.6155
              1040098,0,278834.5748,5047544.9094,-0.0915
              1031086,1,278841.8706,5047531.9172,0.2583
              1030086,0,278829.7600,5047553.3932,-0.1949
              1051105,1,278836.3819,5047541.6777,0.0044
              1050105,0,278834.9452,5047544.2543,-0.0416
1041099;1;275,198;271,106~52;278834.3798,5047544.7102,-0.0785;278834.4395,5047544.4931,6.6252
              1040099,0,278834.3798,5047544.7102,-0.0785
              1031087,1,278843.1799,5047529.2017,0.3369
              1030087,0,278828.5523,5047554.8858,-0.2206
              1051106,1,278837.1271,5047539.8641,0.0703
              1050106,0,278835.0971,5047543.4518,-0.0098
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******** CHO_105_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 105
Image Sequence         : 0
Number of Entities     : 2
1050105;-1;336,235;331,129~52;278834.6173,5047544.9242,-0.1026;278833.4156,5047546.9576,6.6791
              1051105,1,278834.6173,5047544.9242,-0.1026
              1040098,0,278835.1656,5047543.7887,-0.0570
              1041098,1,278834.9452,5047544.2543,-0.0416
              1060113,0,278835.8480,5047542.4476,0.0693
              1061113,1,278831.9698,5047550.3460,-0.2841
1050106;1;333,235;328,129~52;278834.4480,5047544.7613,-0.0914;278833.2349,5047546.7986,6.6865
              1051106,1,278834.4480,5047544.7613,-0.0914
              1040099,0,278835.7148,5047542.1895,-0.0010
              1041099,1,278835.0971,5047543.4518,-0.0098
              1060114,0,278835.3443,5047542.9851,0.0528
              1061114,1,278832.3064,5047549.0930,-0.2265
============================
******** CHO_105_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 105
Image Sequence         : 1
Number of Entities     : 2
1051105;-1;290,203;285,95~52;278834.6173,5047544.9242,-0.1026;278833.4156,5047546.9576,6.6791
              1050105,0,278834.6173,5047544.9242,-0.1026
              1041098,1,278836.3819,5047541.6777,0.0044
              1040098,0,278833.5596,5047546.8717,-0.1963
              1061113,1,278836.7163,5047541.0767,0.0544
              1060113,0,278835.2372,5047543.7948,-0.0211
```

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1051106;1;287,203;282,95~52;278834.4480,5047544.7613,-0.0914;278833.2349,5047546.7986,6.6865
                1050106,0,278834.4480,5047544.7613,-0.0914
                1041099,1,278837.1271,5047539.8641,0.0703
                1040099,0,278832.2551,5047548.7652,-0.2522
                1061114,1,278836.0933,5047541.7869,0.0322
                1060114,0,278834.9079,5047543.9372,-0.0207
============================
******** CHO_106_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 106
Image Sequence         : 0
Number of Entities     : 2
1060113;-1;361,244;355,112~52;278834.4353,5047545.5692,-0.0583;278834.2118,5047545.8025,6.7724
                1061113,1,278834.4353,5047545.5692,-0.0583
                1050105,0,278835.8480,5047542.4476,0.0693
                1051105,1,278835.2372,5047543.7948,-0.0211
                1070122,0,278834.9821,5047544.3720,0.0313
                1071122,1,278835.5058,5047543.3015,0.0548
1060114;1;357,244;351,112~52;278834.2502,5047545.3745,-0.0423;278834.0186,5047545.6257,6.7822
                1061114,1,278834.2502,5047545.3745,-0.0423
                1050106,0,278835.3443,5047542.9851,0.0528
                1051106,1,278834.9079,5047543.9372,-0.0207
                1070123,0,278835.2090,5047543.3129,0.0890
                1071123,1,278834.7218,5047544.4634,-0.0013
============================
******** CHO_106_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 106
Image Sequence         : 1
Number of Entities     : 2
1061113;-1;310,212;303,81~52;278834.4353,5047545.5692,-0.0583;278834.2118,5047545.8025,6.7724
                1060113,0,278834.4353,5047545.5692,-0.0583
                1051105,1,278836.7163,5047541.0767,0.0544
                1050105,0,278831.9698,5047550.3460,-0.2841
                1071122,1,278834.8453,5047544.7713,-0.0596
                1070122,0,278834.6752,5047545.1132,-0.0442
1061114;1;306,212;299,81~52;278834.2502,5047545.3745,-0.0423;278834.0186,5047545.6257,6.7822
                1060114,0,278834.2502,5047545.3745,-0.0423
                1051106,1,278836.0933,5047541.7869,0.0322
                1050106,0,278832.3064,5047549.0930,-0.2265
                1071123,1,278835.2253,5047543.5088,0.0140
                1070123,0,278834.7297,5047544.4646,-0.0054
============================
******** CHO_107_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 107
Image Sequence         : 0
Number of Entities     : 4
1070119;-1;294,236;292,170~32;278809.7378,5047579.9346,0.2230;278812.3056,5047575.4253,6.0751
                1071119,1,278809.7378,5047579.9346,0.2230
                1080013,0,278805.8109,5047586.8597,0.0911
                1081013,1,278811.3629,5047577.0545,0.3554
1070120;1;291,237;288,169~32;278809.4918,5047579.6725,0.1487;278807.7789,5047582.4790,6.6252
                1071120,1,278809.4918,5047579.6725,0.1487
                1080014,0,278808.6386,5047581.1235,0.1213
                1081014,1,278810.1273,5047578.5513,0.2401
1070122;-1;385,260;377,101~52;278834.6683,5047545.1448,-0.0483;278834.3226,5047545.5210,6.6369
                1071122,1,278834.6683,5047545.1448,-0.0483
                1060113,0,278834.9821,5047544.3720,0.0313
                1061113,1,278834.6752,5047545.1132,-0.0442
                1080018,0,278833.9309,5047546.9474,-0.1310
                1081018,1,278835.9718,5047541.8006,0.2004
1070123;1;381,260;374,101~52;278834.5203,5047544.9860,-0.0358;278834.2075,5047545.4095,6.6409
                1071123,1,278834.5203,5047544.9860,-0.0358
                1060114,0,278835.2090,5047543.3129,0.0890
                1061114,1,278834.7297,5047544.4646,-0.0054
                1080019,0,278833.8021,5047546.7149,-0.1145
                1081019,1,278835.8229,5047541.7125,0.2081
============================
******** CHO_107_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
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Number of Pair         : 107
Image Sequence         : 1
Number of Entities     : 4
1071119;-1;257,204;253,137~32;278809.7378,5047579.9346,0.2230;278812.3056,5047575.4253,6.0751
                1070119,0,278809.7378,5047579.9346,0.2230
                1081013,1,278802.4519,5047592.1031,-0.0962
                1080013,0,278808.2893,5047582.3598,0.1643
1071120;1;254,205;251,137~32;278809.4918,5047579.6725,0.1487;278807.7789,5047582.4790,6.6252
                1070120,0,278809.4918,5047579.6725,0.1487
                1081014,1,278804.1718,5047588.4854,-0.0837
                1080014,0,278808.6186,5047581.1172,0.0773
1071122;-1;326,228;317,66~52;278834.6683,5047545.1448,-0.0483;278834.3226,5047545.5210,6.6369
                1070122,0,278834.6683,5047545.1448,-0.0483
                1061113,1,278834.8453,5047544.7713,-0.0596
                1060113,0,278835.5058,5047543.3015,0.0548
                1081018,1,278833.5298,5047547.5398,-0.2440
                1080018,0,278834.1636,5047546.2269,-0.1168
1071123;1;322,228;314,66~52;278834.5203,5047544.9860,-0.0358;278834.2075,5047545.4095,6.6409
                1070123,0,278834.5203,5047544.9860,-0.0358
                1061114,1,278835.2253,5047543.5088,0.0140
                1060114,0,278834.7218,5047544.4634,-0.0013
                1081019,1,278833.3992,5047547.3100,-0.2242
                1080019,0,278834.0335,5047546.0145,-0.1000
============================
******** CHO_108_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 108
Image Sequence         : 0
Number of Entities     : 4
1080013;-1;296,233;292,156~52;278809.3308,5047580.4876,0.2703;278809.5318,5047579.8035,6.6814
                1081013,1,278809.3308,5047580.4876,0.2703
                1070119,0,278805.8109,5047586.8597,0.0911
                1071119,1,278808.2893,5047582.3598,0.1643
                1090131,0,278817.9141,5047565.0047,0.7668
                1091131,1,278805.0127,5047588.3456,-0.0493
1080014;1;293,235;290,154~52;278809.1557,5047580.1657,0.1645;278809.3025,5047579.8077,6.8223
                1081014,1,278809.1557,5047580.1657,0.1645
                1070120,0,278808.6386,5047581.1235,0.1213
                1071120,1,278808.6186,5047581.1172,0.0773
                1090132,0,278818.9323,5047562.7150,0.7358
                1091132,1,278802.4092,5047592.2286,-0.2654
1080018;-1;426,270;416,58~32;278834.5812,5047544.9991,-0.0175;278834.2221,5047545.4812,6.7246
                1081018,1,278834.5812,5047544.9991,-0.0175
                1070122,0,278833.9309,5047546.9474,-0.1310
                1071122,1,278834.1636,5047546.2269,-0.1168
1080019;1;421,270;413,58~32;278834.4411,5047544.8428,-0.0043;278834.1332,5047545.3971,6.7270
                1081019,1,278834.4411,5047544.8428,-0.0043
                1070123,0,278833.8021,5047546.7149,-0.1145
                1071123,1,278834.0335,5047546.0145,-0.1000
============================
******** CHO_108_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 108
Image Sequence         : 1
Number of Entities     : 4
1081013;-1;257,200;252,122~52;278809.3308,5047580.4876,0.2703;278809.5318,5047579.8035,6.6814
                1080013,0,278809.3308,5047580.4876,0.2703
                1071119,1,278802.4519,5047592.1031,-0.0962
                1070119,0,278811.3629,5047577.0545,0.3554
                1091131,1,278822.5133,5047558.2047,0.9371
                1090131,0,278812.3761,5047575.3375,0.4445
1081014;1;254,201;250,121~52;278809.1557,5047580.1657,0.1645;278809.3025,5047579.8077,6.8223
                1080014,0,278809.1557,5047580.1657,0.1645
                1071120,1,278804.1718,5047588.4854,-0.0837
                1070120,0,278810.1273,5047578.5513,0.2401
                1091132,1,278822.9929,5047557.0496,0.9554
                1090132,0,278812.7177,5047574.2016,0.3866
1081018;-1;354,238;343,23~32;278834.5812,5047544.9991,-0.0175;278834.2221,5047545.4812,6.7246
                1080018,0,278834.5812,5047544.9991,-0.0175
                1071122,1,278833.5298,5047547.5398,-0.2440
                1070122,0,278835.9718,5047541.8006,0.2004
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1081019;1;349,238;340,23~32;278834.4411,5047544.8428,-0.0043;278834.1332,5047545.3971,6.7270
                1080019,0,278834.4411,5047544.8428,-0.0043
                1071123,1,278833.3992,5047547.3100,-0.2242
                1070123,0,278835.8229,5047541.7125,0.2081
============================
******** CHO_109_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 109
Image Sequence         : 0
Number of Entities     : 4
1090131;-1;309,230;305,141~52;278809.8345,5047580.0794,0.2352;278808.4688,5047582.3969,6.8150
                1091131,1,278809.8345,5047580.0794,0.2352
                1080013,0,278817.9141,5047565.0047,0.7668
                1081013,1,278812.3761,5047575.3375,0.4445
                1100135,0,278808.8029,5047581.9835,0.2321
                1101135,1,278809.4769,5047580.7436,0.2728
1090132;1;306,232;303,143~52;278809.4312,5047580.2501,0.1650;278809.4564,5047580.1774,6.5746
                1091132,1,278809.4312,5047580.2501,0.1650
                1080014,0,278818.9323,5047562.7150,0.7358
                1081014,1,278812.7177,5047574.2016,0.3866
                1100136,0,278808.8968,5047581.2598,0.1912
                1101136,1,278807.8669,5047583.1188,0.0836
1090207;-1;460,201;458,155~1;278801.7038,5047652.8103,1.4320;278801.7038,5047652.8103,8.2270
1090206;1;467,198;467,155~1;278800.3098,5047662.8124,1.7929;278800.3098,5047662.8124,8.5879
============================
******** CHO_109_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 109
Image Sequence         : 1
Number of Entities     : 2
1091131;-1;267,199;263,110~52;278809.8345,5047580.0794,0.2352;278808.4688,5047582.3969,6.8150
                1090131,0,278809.8345,5047580.0794,0.2352
                1081013,1,278822.5133,5047558.2047,0.9371
                1080013,0,278805.0127,5047588.3456,-0.0493
                1101135,1,278809.2027,5047581.2065,0.1825
                1100135,0,278809.2130,5047581.1686,0.1890
1091132;1;264,199;260,110~52;278809.4312,5047580.2501,0.1650;278809.4564,5047580.1774,6.5746
                1090132,0,278809.4312,5047580.2501,0.1650
                1081014,1,278822.9929,5047557.0496,0.9554
                1080014,0,278802.4092,5047592.2286,-0.2654
                1101136,1,278810.4979,5047578.4542,0.2662
                1100136,0,278809.3754,5047580.3559,0.2276
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******** CHO_110_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 110
Image Sequence         : 0
Number of Entities     : 4
1100135;-1;328,234;323,132~52;278808.9684,5047581.6546,0.2296;278808.8416,5047581.6240,6.8031
                1101135,1,278808.9684,5047581.6546,0.2296
                1090131,0,278808.8029,5047581.9835,0.2321
                1091131,1,278809.2130,5047581.1686,0.1890
                1110150,0,278805.7904,5047587.7837,-0.0689
                1111150,1,278813.1131,5047573.6124,0.5531
1100136;1;325,234;320,131~52;278808.8532,5047581.3715,0.2160;278808.5971,5047581.5881,6.8563
                1101136,1,278808.8532,5047581.3715,0.2160
                1090132,0,278808.8968,5047581.2598,0.1912
                1091132,1,278809.3754,5047580.3559,0.2276
                1110151,0,278805.4680,5047587.7986,-0.0951
                1111151,1,278814.6757,5047570.1917,0.6925
1100140;-1;420,239;419,213~1;278756.5239,5047746.8153,-8.3832;278756.5239,5047746.8153,-1.5882
1100142;1;410,239;409,212~1;278756.9221,5047737.0789,-7.8451;278756.9221,5047737.0789,-1.0501
============================
******** CHO_110_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 110
Image Sequence         : 1
Number of Entities     : 4
1101135;-1;283,201;277,97~52;278808.9684,5047581.6546,0.2296;278808.8416,5047581.6240,6.8031
                1100135,0,278808.9684,5047581.6546,0.2296
                1091131,1,278809.2027,5047581.2065,0.1825
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                 1090131,0,278809.4769,5047580.7436,0.2728
                 1111150,1,278806.8003,5047585.4633,0.0170
                 1110150,0,278807.3509,5047584.5194,0.0707
1101136;1;280,202;274,97~52;278808.8532,5047581.3715,0.2160;278808.5971,5047581.5881,6.8563
                 1100136,0,278808.8532,5047581.3715,0.2160
                 1091132,1,278810.4979,5047578.4542,0.2662
                 1090132,0,278807.8669,5047583.1188,0.0836
                 1111151,1,278804.2913,5047589.3358,-0.2162
                 1110151,0,278806.9318,5047584.7430,0.0041
1101140;-1;361,207;359,180~1;278752.2407,5047730.7854,-8.1340;278752.2407,5047730.7854,-1.3390
1101142;1;349,204;349,178~1;278745.7864,5047737.2577,-7.5680;278745.7864,5047737.2577,-0.7730
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******** CHO_111_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 111
Image Sequence         : 0
Number of Entities     : 2
1110150;-1;353,238;348,116~52;278807.9424,5047583.2807,0.0811;278808.3705,5047582.1392,6.7527
                 1111150,1,278807.9424,5047583.2807,0.0811
                 1100135,0,278805.7904,5047587.7837,-0.0689
                 1101135,1,278807.3509,5047584.5194,0.0707
                 1120158,0,278809.6984,5047579.6636,0.3046
                 1121158,1,278806.0849,5047587.2485,-0.1524
1110151;1;349,239;345,116~52;278808.4415,5047581.6465,0.1140;278808.1956,5047582.0492,6.7387
                 1111151,1,278808.4415,5047581.6465,0.1140
                 1100136,0,278805.4680,5047587.7986,-0.0951
                 1101136,1,278806.9318,5047584.7430,0.0041
                 1120159,0,278809.9406,5047578.6211,0.3388
                 1121159,1,278803.6875,5047591.3877,-0.3829
============================
******** CHO_111_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 111
Image Sequence         : 1
Number of Entities     : 4
1111147;-1;355,197;354,177~1;278713.1197,5047805.3411,-8.7973;278713.1197,5047805.3411,-2.0023
1111149;1;345,201;345,178~1;278725.4435,5047769.1935,-8.3701;278725.4435,5047769.1935,-1.5751
1111150;-1;304,205;297,81~52;278807.9424,5047583.2807,0.0811;278808.3705,5047582.1392,6.7527
                 1110150,0,278807.9424,5047583.2807,0.0811
                 1101135,1,278806.8003,5047585.4633,0.0170
                 1100135,0,278813.1131,5047573.6124,0.5531
                 1121158,1,278810.2298,5047579.0200,0.2984
                 1120158,0,278808.9162,5047581.4710,0.1962
1111151;1;299,206;294,82~52;278808.4415,5047581.6465,0.1140;278808.1956,5047582.0492,6.7387
                 1110151,0,278808.4415,5047581.6465,0.1140
                 1101136,1,278804.2913,5047589.3358,-0.2162
                 1100136,0,278814.6757,5047570.1917,0.6925
                 1121159,1,278810.5517,5047577.8181,0.3670
                 1120159,0,278809.3062,5047580.0754,0.2516
============================
******** CHO_112_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 112
Image Sequence         : 0
Number of Entities     : 2
1120158;-1;386,249;379,95~52;278808.2606,5047582.9899,0.1033;278807.8628,5047583.4646,7.0608
                 1121158,1,278808.2606,5047582.9899,0.1033
                 1110150,0,278809.6984,5047579.6636,0.3046
                 1111150,1,278808.9162,5047581.4710,0.1962
                 1130024,0,278807.2787,5047585.2535,0.0262
                 1131024,1,278807.1311,5047585.3837,0.0158
1120159;1;382,249;376,92~52;278808.4989,5047581.9193,0.1943;278808.1433,5047582.4456,7.0970
                 1121159,1,278808.4989,5047581.9193,0.1943
                 1110151,0,278809.9406,5047578.6211,0.3388
                 1111151,1,278809.3062,5047580.0754,0.2516
                 1130025,0,278807.4096,5047584.3978,0.0849
                 1131025,1,278806.2837,5047586.8421,-0.0829
============================
******** CHO_112_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 112
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Image Sequence         : 1
Number of Entities     : 2
1121158;-1;330,217;322,63~52;278808.2606,5047582.9899,0.1033;278807.8628,5047583.4646,7.0608
               1120158,0,278808.2606,5047582.9899,0.1033
               1111150,1,278810.2298,5047579.0200,0.2984
               1110150,0,278806.0849,5047587.2485,-0.1524
               1131024,1,278806.5673,5047586.4294,-0.0997
               1130024,0,278807.6300,5047584.2795,0.0522
1121159;1;325,216;318,59~52;278808.4989,5047581.9193,0.1943;278808.1433,5047582.4456,7.0970
               1120159,0,278808.4989,5047581.9193,0.1943
               1111151,1,278810.5517,5047577.8181,0.3670
               1110151,0,278803.6875,5047591.3877,-0.3829
               1131025,1,278807.7493,5047583.4323,0.1371
               1130025,0,278807.8413,5047583.2329,0.1502
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******** CHO_113_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 113
Image Sequence         : 0
Number of Entities     : 8
1130024;-1;429,259;422,70~32;278808.1585,5047582.8552,0.2288;278808.0866,5047582.7237,6.6196
               1131024,1,278808.1585,5047582.8552,0.2288
               1120158,0,278807.2787,5047585.2535,0.0262
               1121158,1,278807.6300,5047584.2795,0.0522
1130025;1;425,259;418,69~32;278807.8190,5047583.3125,0.1943;278807.9640,5047582.6021,6.6406
               1131025,1,278807.8190,5047583.3125,0.1943
               1120159,0,278807.4096,5047584.3978,0.0849
               1121159,1,278807.8413,5047583.2329,0.1502
1130028;-1;318,238;316,159~32;278784.3069,5047616.6261,-0.5981;278786.3127,5047613.0701,5.7865
               1131028,1,278784.3069,5047616.6261,-0.5981
               1140171,0,278784.3990,5047616.4719,-0.5637
               1141171,1,278782.4080,5047620.0722,-0.7564
1130029;1;314,238;313,159~32;278782.1187,5047619.7066,-0.6932;278784.4462,5047615.8341,5.9738
               1131029,1,278782.1187,5047619.7066,-0.6932
               1140172,0,278787.9762,5047609.2542,-0.1958
               1141172,1,278780.8560,5047621.9691,-0.8462
1130032;-1;291,234;290,183~12;278761.7219,5047648.7108,-1.5303;278767.8124,5047638.8012,4.8301
               1131032,1,278761.7219,5047648.7108,-1.5303
1130033;1;288,234;288,181~12;278761.3796,5047648.3509,-1.5033;278767.5230,5047638.7466,5.0791
               1131033,1,278761.3796,5047648.3509,-1.5033
1130064;-1;135,207;135,163~1;278726.7419,5047650.0137,3.1736;278726.7419,5047650.0137,9.9686
1130065;1;132,206;133,161~1;278728.5821,5047647.4672,3.3151;278728.5821,5047647.4672,10.1101
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******** CHO_113_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 113
Image Sequence         : 1
Number of Entities     : 6
1131024;-1;361,225;352,36~32;278808.1585,5047582.8552,0.2288;278808.0866,5047582.7237,6.6196
               1130024,0,278808.1585,5047582.8552,0.2288
               1121158,1,278806.5673,5047586.4294,-0.0997
               1120158,0,278807.1311,5047585.3837,0.0158
1131025;1;358,225;348,36~32;278807.8190,5047583.3125,0.1943;278807.9640,5047582.6021,6.6406
               1130025,0,278807.8190,5047583.3125,0.1943
               1121159,1,278807.7493,5047583.4323,0.1371
               1120159,0,278806.2837,5047586.8421,-0.0829
1131028;-1;279,205;275,126~32;278784.3069,5047616.6261,-0.5981;278786.3127,5047613.0701,5.7865
               1130028,0,278784.3069,5047616.6261,-0.5981
               1141171,1,278786.2133,5047613.4154,-0.4273
               1140171,0,278784.4023,5047616.4711,-0.5747
1131029;1;276,204;273,126~32;278782.1187,5047619.7066,-0.6932;278784.4462,5047615.8341,5.9738
               1130029,0,278782.1187,5047619.7066,-0.6932
               1141172,1,278785.6810,5047613.7000,-0.3947
               1140172,0,278784.7008,5047615.3633,-0.4723
1131032;-1;259,201;256,150~12;278761.7219,5047648.7108,-1.5303;278767.8124,5047638.8012,4.8301
               1130032,0,278761.7219,5047648.7108,-1.5303
1131033;1;256,201;254,148~12;278761.3796,5047648.3509,-1.5033;278767.5230,5047638.7466,5.0791
               1130033,0,278761.3796,5047648.3509,-1.5033
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******** CHO_114_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
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Number of Pair         : 114
Image Sequence         : 0
Number of Entities     : 6
1140169;-1;119,221;117,156~12;278759.2096,5047616.2425,1.2547;278755.9922,5047619.5381,7.2699
               1141169,1,278759.2096,5047616.2425,1.2547
1140170;1;116,221;115,156~12;278761.4679,5047613.5404,1.2779;278761.5528,5047613.6729,6.7916
               1141170,1,278761.4679,5047613.5404,1.2779
1140171;-1;323,239;321,149~52;278783.4867,5047618.1955,-0.6498;278783.5768,5047618.0436,6.1422
               1141171,1,278783.4867,5047618.1955,-0.6498
               1130028,0,278784.3990,5047616.4719,-0.5637
               1131028,1,278784.4023,5047616.4711,-0.5747
               1150188,0,278784.1857,5047616.9069,-0.5397
               1151188,1,278781.5053,5047621.9095,-0.8367
1140172;1;320,239;318,148~52;278784.6477,5047615.4567,-0.4985;278783.4395,5047617.7264,6.1799
               1141172,1,278784.6477,5047615.4567,-0.4985
               1130029,0,278787.9762,5047609.2542,-0.1958
               1131029,1,278784.7008,5047615.3633,-0.4723
               1150189,0,278783.4252,5047617.7213,-0.6175
               1151189,1,278782.4411,5047619.5422,-0.6978
1140178;-1;504,280;496,34~12;278808.0323,5047583.8479,0.1504;278807.9788,5047583.5334,6.2078
               1141178,1,278808.0323,5047583.8479,0.1504
1140179;1;496,281;491,34~12;278807.8484,5047583.6438,0.1288;278807.9295,5047583.1571,6.1867
               1141179,1,278807.8484,5047583.6438,0.1288
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******** CHO_114_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 114
Image Sequence         : 1
Number of Entities     : 6
1141169;-1;80,189;78,125~12;278759.2096,5047616.2425,1.2547;278755.9922,5047619.5381,7.2699
               1140169,0,278759.2096,5047616.2425,1.2547
1141170;1;76,190;74,125~12;278761.4679,5047613.5404,1.2779;278761.5528,5047613.6729,6.7916
               1140170,0,278761.4679,5047613.5404,1.2779
1141171;-1;282,206;279,116~52;278783.4867,5047618.1955,-0.6498;278783.5768,5047618.0436,6.1422
               1140171,0,278783.4867,5047618.1955,-0.6498
               1131028,1,278786.2133,5047613.4154,-0.4273
               1130028,0,278782.4080,5047620.0722,-0.7564
               1151188,1,278784.8492,5047615.8501,-0.4982
               1150188,0,278783.8753,5047617.5280,-0.5846
1141172;1;278,206;276,116~52;278784.6477,5047615.4567,-0.4985;278783.4395,5047617.7264,6.1799
               1140172,0,278784.6477,5047615.4567,-0.4985
               1131029,1,278785.6810,5047613.7000,-0.3947
               1130029,0,278780.8560,5047621.9691,-0.8462
               1151189,1,278786.0087,5047613.1528,-0.3373
               1150189,0,278784.1409,5047616.3305,-0.5444
1141178;-1;418,244;408,2~12;278808.0323,5047583.8479,0.1504;278807.9788,5047583.5334,6.2078
               1140178,0,278808.0323,5047583.8479,0.1504
1141179;1;410,246;402,0~12;278807.8484,5047583.6438,0.1288;278807.9295,5047583.1571,6.1867
               1140179,0,278807.8484,5047583.6438,0.1288
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******** CHO_115_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 115
Image Sequence         : 0
Number of Entities     : 4
1150184;-1;104,248;100,161~32;278758.8727,5047616.6148,-0.8609;278758.0370,5047617.3625,6.1459
               1151184,1,278758.8727,5047616.6148,-0.8609
               1160072,0,278761.0110,5047614.5730,-0.7198
               1161072,1,278759.4733,5047616.0478,-0.8486
1150185;1;100,249;97,162~32;278760.5466,5047614.4928,-0.7525;278757.3410,5047617.6158,6.1488
               1151185,1,278760.5466,5047614.4928,-0.7525
               1160071,0,278758.9173,5047616.0433,-0.8685
               1161071,1,278758.3065,5047616.6253,-0.9312
1150188;-1;335,243;332,142~52;278783.2653,5047618.7355,-0.6295;278783.2219,5047618.7278,6.1363
               1151188,1,278783.2653,5047618.7355,-0.6295
               1140171,0,278784.1857,5047616.9069,-0.5397
               1141171,1,278783.8753,5047617.5280,-0.5846
               1160069,0,278783.2991,5047618.6796,-0.6002
               1161069,1,278781.7461,5047621.6991,-0.7775
1150189;1;331,244;330,143~52;278783.0237,5047618.4959,-0.6453;278784.0726,5047616.7119,5.9057
               1151189,1,278783.0237,5047618.4959,-0.6453
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              1140172,0,278783.4252,5047617.7213,-0.6175
              1141172,1,278784.1409,5047616.3305,-0.5444
              1160070,0,278784.7859,5047615.1203,-0.4025
              1161070,1,278780.2635,5047623.8183,-0.9799
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******** CHO_115_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 115
Image Sequence         : 1
Number of Entities     : 4
1151184;-1;63,219;58,132~32;278758.8727,5047616.6148,-0.8609;278758.0370,5047617.3625,6.1459
              1150184,0,278758.8727,5047616.6148,-0.8609
              1161072,1,278759.9338,5047615.6581,-0.8608
              1160072,0,278759.9871,5047615.5600,-0.8332
1151185;1;58,219;55,132~32;278760.5466,5047614.4928,-0.7525;278757.3410,5047617.6158,6.1488
              1150185,0,278760.5466,5047614.4928,-0.7525
              1161071,1,278756.2687,5047618.3379,-1.0605
              1160071,0,278762.7009,5047612.6035,-0.6108
1151188;-1;291,210;287,107~52;278783.2653,5047618.7355,-0.6295;278783.2219,5047618.7278,6.1363
              1150188,0,278783.2653,5047618.7355,-0.6295
              1141171,1,278784.8492,5047615.8501,-0.4982
              1140171,0,278781.5053,5047621.9095,-0.8367
              1161069,1,278783.4800,5047618.3813,-0.5756
              1160069,0,278783.3027,5047618.6753,-0.6112
1151189;1;287,210;284,109~52;278783.0237,5047618.4959,-0.6453;278784.0726,5047616.7119,5.9057
              1150189,0,278783.0237,5047618.4959,-0.6453
              1141172,1,278786.0087,5047613.1528,-0.3373
              1140172,0,278782.4411,5047619.5422,-0.6978
              1161070,1,278784.6706,5047615.5923,-0.4173
              1160070,0,278783.9910,5047616.7859,-0.4865
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******** CHO_116_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 116
Image Sequence         : 0
Number of Entities     : 6
1160067;-1;300,232;297,167~32;278762.7178,5047647.5596,-1.3663;278760.9719,5047650.3114,5.1090
              1161067,1,278762.7178,5047647.5596,-1.3663
              1170192,0,278755.8148,5047659.6067,-1.9776
              1171192,1,278762.6875,5047647.6028,-1.2517
1160068;1;297,232;295,166~32;278762.4505,5047647.2967,-1.3467;278760.7449,5047650.2106,5.2234
              1161068,1,278762.4505,5047647.2967,-1.3467
              1170193,0,278757.3863,5047656.0519,-1.7838
              1171193,1,278761.3215,5047649.2318,-1.3772
1160069;-1;351,244;348,129~52;278782.9826,5047619.3513,-0.6149;278783.5359,5047618.1530,5.8531
              1161069,1,278782.9826,5047619.3513,-0.6149
              1150188,0,278783.2991,5047618.6796,-0.6002
              1151188,1,278783.3027,5047618.6753,-0.6112
              1170194,0,278784.2884,5047616.6498,-0.4137
              1171194,1,278780.4435,5047624.6386,-0.9905
1160070;1;348,244;345,128~52;278783.5776,5047617.6470,-0.5245;278783.3798,5047618.0168,5.8881
              1161070,1,278783.5776,5047617.6470,-0.5245
              1150189,0,278784.7859,5047615.1203,-0.4025
              1151189,1,278783.9910,5047616.7859,-0.4865
              1170195,0,278783.2763,5047618.2846,-0.5338
              1171195,1,278782.7423,5047619.3588,-0.6247
1160072;-1;83,251;79,145~42;278758.1233,5047617.2094,-0.9901;278758.5320,5047616.9325,6.5128
              1161072,1,278758.1233,5047617.2094,-0.9901
              1150184,0,278761.0110,5047614.5730,-0.7198
              1151184,1,278759.9871,5047615.5600,-0.8332
              1170198,0,278759.5710,5047615.9068,-0.9036
1160071;1;79,251;76,145~42;278757.6670,5047617.1691,-0.9867;278756.1041,5047618.7966,6.7955
              1161071,1,278757.6670,5047617.1691,-0.9867
              1150185,0,278758.9173,5047616.0433,-0.8685
              1151185,1,278762.7009,5047612.6035,-0.6108
              1170199,0,278759.6614,5047615.3878,-0.8609
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******** CHO_116_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 116
Image Sequence         : 1
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Number of Entities     : 6
1161067;-1;264,199;261,135~32;278762.7178,5047647.5596,-1.3663;278760.9719,5047650.3114,5.1090
               1160067,0,278762.7178,5047647.5596,-1.3663
               1171192,1,278759.7830,5047652.4376,-1.5107
               1170192,0,278760.8439,5047650.6609,-1.5050
1161068;1;261,199;259,134~32;278762.4505,5047647.2967,-1.3467;278760.7449,5047650.2106,5.2234
               1160068,0,278762.4505,5047647.2967,-1.3467
               1171193,1,278761.0334,5047649.6551,-1.4028
               1170193,0,278761.1491,5047649.4310,-1.4332
1161069;-1;303,210;298,95~52;278782.9826,5047619.3513,-0.6149;278783.5359,5047618.1530,5.8531
               1160069,0,278782.9826,5047619.3513,-0.6149
               1151188,1,278783.4800,5047618.3813,-0.5756
               1150188,0,278781.7461,5047621.6991,-0.7775
               1171194,1,278784.0118,5047617.4315,-0.4434
               1170194,0,278783.7352,5047617.9372,-0.4912
1161070;1;299,211;295,95~52;278783.5776,5047617.6470,-0.5245;278783.3798,5047618.0168,5.8881
               1160070,0,278783.5776,5047617.6470,-0.5245
               1151189,1,278784.6706,5047615.5923,-0.4173
               1150189,0,278780.2635,5047623.8183,-0.9799
               1171195,1,278783.6181,5047617.5940,-0.5031
               1170195,0,278783.4642,5047617.8679,-0.5129
1161072;-1;39,222;33,115~42;278758.1233,5047617.2094,-0.9901;278758.5320,5047616.9325,6.5128
               1160072,0,278758.1233,5047617.2094,-0.9901
               1151184,1,278759.9338,5047615.6581,-0.8608
               1150184,0,278759.4733,5047616.0478,-0.8486
               1170198,0,278763.4591,5047612.6433,-0.6322
1161071;1;35,222;31,113~42;278757.6670,5047617.1691,-0.9867;278756.1041,5047618.7966,6.7955
               1160071,0,278757.6670,5047617.1691,-0.9867
               1151185,1,278756.2687,5047618.3379,-1.0605
               1150185,0,278758.3065,5047616.6253,-0.9312
               1170199,0,278764.3467,5047611.5087,-0.5318
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******** CHO_117_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 117
Image Sequence         : 0
Number of Entities     : 6
1170192;-1;305,231;302,157~42;278760.9992,5047650.4091,-1.3759;278759.0539,5047653.6282,5.4880
               1171192,1,278760.9992,5047650.4091,-1.3759
               1160067,0,278755.8148,5047659.6067,-1.9776
               1161067,1,278760.8439,5047650.6609,-1.5050
               1181201,1,278759.7482,5047652.6248,-1.6030
1170193;1;302,231;300,158~42;278760.5737,5047650.4552,-1.4198;278761.0188,5047649.6784,5.2835
               1171193,1,278760.5737,5047650.4552,-1.4198
               1160068,0,278757.3863,5047656.0519,-1.7838
               1161068,1,278761.1491,5047649.4310,-1.4332
               1181200,1,278758.4511,5047654.1978,-1.6905
1170194;-1;376,248;372,107~52;278783.4983,5047618.4845,-0.5132;278784.0782,5047617.0213,5.8076
               1171194,1,278783.4983,5047618.4845,-0.5132
               1160069,0,278784.2884,5047616.6498,-0.4137
               1161069,1,278783.7352,5047617.9372,-0.4912
               1180079,0,278782.6374,5047620.4499,-0.6885
               1181079,1,278784.7439,5047615.6367,-0.3034
1170195;1;371,248;368,107~52;278783.3092,5047618.2281,-0.5157;278783.4892,5047617.8295,5.9120
               1171195,1,278783.3092,5047618.2281,-0.5157
               1160070,0,278783.2763,5047618.2846,-0.5338
               1161070,1,278783.4642,5047617.8679,-0.5129
               1180081,0,278783.2663,5047618.3128,-0.5270
               1181081,1,278783.5874,5047617.7014,-0.4857
1170198;-1;56,257;51,138~32;278759.5710,5047615.9068,-0.9036;278758.1960,5047617.2010,6.3867
               1160072,0,278759.5710,5047615.9068,-0.9036
               1161072,1,278763.4591,5047612.6433,-0.6322
               1180083,0,278760.2865,5047615.3345,-0.9563
1170199;1;51,257;47,138~32;278759.6614,5047615.3878,-0.8609;278758.6954,5047616.4147,6.3275
               1160071,0,278759.6614,5047615.3878,-0.8609
               1161071,1,278764.3467,5047611.5087,-0.5318
               1180082,0,278760.1884,5047614.9879,-0.9503
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******** CHO_117_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 117
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Image Sequence         : 1
Number of Entities     : 4
1171192;-1;268,196;265,125~42;278760.9992,5047650.4091,-1.3759;278759.0539,5047653.6282,5.4880
              1170192,0,278760.9992,5047650.4091,-1.3759
              1161067,1,278759.7830,5047652.4376,-1.5107
              1160067,0,278762.6875,5047647.6028,-1.2517
              1181201,1,278767.5870,5047639.2885,-0.7560
1171193;1;265,197;262,125~42;278760.5737,5047650.4552,-1.4198;278761.0188,5047649.6784,5.2835
              1170193,0,278760.5737,5047650.4552,-1.4198
              1161068,1,278761.0334,5047649.6551,-1.4028
              1160068,0,278761.3215,5047649.2318,-1.3772
              1181200,1,278766.5176,5047640.5570,-0.8631
1171194;-1;321,214;314,73~52;278783.4983,5047618.4845,-0.5132;278784.0782,5047617.0213,5.8076
              1170194,0,278783.4983,5047618.4845,-0.5132
              1161069,1,278784.0118,5047617.4315,-0.4434
              1160069,0,278780.4435,5047624.6386,-0.9905
              1181079,1,278783.5632,5047618.3160,-0.5277
              1180079,0,278783.0121,5047619.4589,-0.5943
1171195;1;316,215;311,73~52;278783.3092,5047618.2281,-0.5157;278783.4892,5047617.8295,5.9120
              1170195,0,278783.3092,5047618.2281,-0.5157
              1161070,1,278783.6181,5047617.5940,-0.5031
              1160070,0,278782.7423,5047619.3588,-0.6247
              1181081,1,278784.1658,5047616.5330,-0.3925
              1180081,0,278783.2506,5047618.3422,-0.5408
===========================
******** CHO_118_0.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 118
Image Sequence         : 0
Number of Entities     : 4
1180079;-1;410,253;406,74~32;278782.9085,5047619.7296,-0.6685;278783.0452,5047619.1130,6.0055
              1181079,1,278782.9085,5047619.7296,-0.6685
              1170194,0,278782.6374,5047620.4499,-0.6885
              1171194,1,278783.0121,5047619.4589,-0.5943
1180081;1;406,254;403,74~32;278782.7593,5047619.6153,-0.6792;278782.9388,5047619.0271,5.9923
              1181081,1,278782.7593,5047619.6153,-0.6792
              1170195,0,278783.2663,5047618.3128,-0.5270
              1171195,1,278783.2506,5047618.3422,-0.5408
1180083;-1;17,261;10,119~12;278760.2865,5047615.3345,-0.9563;278759.8774,5047615.7028,5.9204
              1170198,0,278760.2865,5047615.3345,-0.9563
1180082;1;11,262;7,118~12;278760.1884,5047614.9879,-0.9503;278758.2180,5047616.7507,6.0988
              1170199,0,278760.1884,5047614.9879,-0.9503
===========================
******** CHO_118_1.dat *********
Stereo Image File Name : C:\MARINE\CHO.fit
Number of Pair         : 118
Image Sequence         : 1
Number of Entities     : 4
1181079;-1;347,221;340,39~32;278782.9085,5047619.7296,-0.6685;278783.0452,5047619.1130,6.0055
              1180079,0,278782.9085,5047619.7296,-0.6685
              1171194,1,278783.5632,5047618.3160,-0.5277
              1170194,0,278784.7439,5047615.6367,-0.3034
1181081;1;343,221;337,40~32;278782.7593,5047619.6153,-0.6792;278782.9388,5047619.0271,5.9923
              1180081,0,278782.7593,5047619.6153,-0.6792
              1171195,1,278784.1658,5047616.5330,-0.3925
              1170195,0,278783.5874,5047617.7014,-0.4857
1181201;-1;273,194;269,113~22;278767.5870,5047639.2885,-0.7560;278754.4399,5047661.3847,5.7739
              1171192,1,278767.5870,5047639.2885,-0.7560
              1170192,0,278759.7482,5047652.6248,-1.6030
1181200;1;270,194;267,113~22;278766.5176,5047640.5570,-0.8631;278761.0137,5047649.7403,5.2338
              1171193,1,278766.5176,5047640.5570,-0.8631
              1170193,0,278758.4511,5047654.1978,-1.6905
```

Appendix B(1). Data Source

```
File Name               : C:\CFM\CFM
Number of Pair          : 7
Number of Entities      : 33
Type of Entity          : Line
Point 1 :
606047.904,230340.651,235.201;78,116;133,115
Point 2 :
606064.498,230327.592,234.237;156,116;201,114
Code :  70000
Type of Entity          : Line
Point 1 :
606064.498,230327.592,234.237;156,116;201,114
Point 2 :
606058.264,230348.732,233.589;167,125;215,122
Code :  70000
Type of Entity          : Line
Point 1 :
606058.264,230348.732,233.589;167,125;215,122
Point 2 :
606056.515,230323.503,232.520;77,127;130,124
Code :  70000
Type of Entity          : Line
Point 1 :
606094.644,230267.024,228.243;436,204;408,200
Point 2 :
606094.686,230264.125,228.118;460,224;410,221
Code :  70000
Type of Entity          : Line
Point 1 :
606078.500,230347.450,230.461;280,142;320,139
Point 2 :
606076.996,230353.526,244.882;279,78;321,75
Code :  70000
Type of Entity          : Line
Point 1 :
606080.901,230326.620,240.731;276,78;318,75
Point 2 :
606076.522,230352.477,229.966;276,142;316,139
Code :  70000
Type of Entity          : Line
Point 1 :
606046.884,230412.095,233.566;197,131;248,127
Point 2 :
606060.986,230351.322,231.894;165,131;212,128
Code :  80000
Type of Entity          : Line
Point 1 :
606057.035,230380.853,231.020;198,138;248,133
Point 2 :
606057.005,230362.045,230.528;166,137;214,136
Code :  80000
Type of Entity          : Line
Point 1 :
606089.013,230276.725,227.889;167,217;131,214
Point 2 :
606088.906,230275.563,227.752;137,234;93,227
Code :  80000
Type of Entity          : Line
Point 1 :
606095.420,230279.213,228.279;439,203;414,198
Point 2 :
606095.441,230276.106,228.173;463,222;415,219
Code :  80000
Type of Entity          : Line
Point 1 :
606078.658,230349.762,243.834;275,70;314,68
Point 2 :
606078.817,230348.094,229.946;274,143;313,140
Code :  80000
Type of Entity          : Line
Point 1 :
606078.027,230348.958,243.589;271,70;310,68
Point 2 :
606077.981,230348.191,229.809;269,143;308,140
Code :  80000
Type of Entity          : Line
Point 1 :
606063.949,230349.362,231.542;147,130;196,129
Point 2 :
606054.880,230393.248,232.647;191,131;241,127
Code :  90000
Type of Entity          : Line
Point 1 :
606054.172,230395.054,230.870;191,137;241,134
Point 2 :
606063.278,230350.731,230.347;147,138;196,135
Code :  90000
Type of Entity          : Line
Point 1 :
606091.184,230302.125,228.394;311,170;320,167
Point 2 :
606093.435,230286.431,228.028;340,235;277,228
Code :  90000
Type of Entity          : Line
Point 1 :
606096.003,230291.275,228.252;440,202;416,198
Point 2 :
606096.123,230288.452,228.161;464,219;421,216
Code :  90000
Type of Entity          : Line
Point 1 :
606078.220,230354.960,244.789;265,57;301,55
Point 2 :
606079.723,230347.158,228.999;264,147;301,144
Code :  90000
Type of Entity          : Line
Point 1 :
606077.685,230354.140,244.621;261,57;297,55
Point 2 :
606078.012,230351.047,229.267;259,147;296,144
Code :  90000
Type of Entity          : Line
Point 1 :
606050.402,230385.711,231.512;132,128;183,127
Point 2 :
606056.028,230394.686,232.362;181,127;231,123
Code :  100000
Type of Entity          : Line
Point 1 :
606058.880,230387.090,230.440;182,134;231,131
Point 2 :
606042.317,230402.373,230.422;130,133;183,132
Code :  100000
Type of Entity          : Line
Point 1 :
606096.631,230303.519,228.228;445,199;424,195
Point 2 :
606096.699,230300.872,228.123;465,215;427,211
Code :  100000
Type of Entity          : Line
Point 1 :
606096.489,230303.340,228.224;441,199;419,196
Point 2 :
606096.557,230300.509,228.161;462,216;421,211
Code :  100000
Type of Entity          : Line
```

```
Point 1 :
606081.214,230344.983,242.664;250,37;284,34
Point 2 :
606081.445,230343.402,228.669;250,147;284,144
Code :  100000
Type of Entity          : Line
Point 1 :
606082.105,230339.679,241.447;246,37;279,34
Point 2 :
606080.487,230344.364,228.616;244,147;278,144
Code :  100000
Type of Entity          : Line
Point 1 :
606065.335,230361.793,231.055;117,130;163,127
Point 2 :
606060.758,230387.644,231.584;167,130;216,127
Code :  110000
Type of Entity          : Line
Point 1 :
606060.758,230387.644,231.584;167,130;216,127
Point 2 :
606048.651,230416.726,230.303;166,136;216,134
Code :  110000
Type of Entity          : Line
Point 1 :
606048.651,230416.726,230.303;166,136;216,134
Point 2 :
606059.006,230373.440,230.362;110,135;164,134
Code :  110000
Type of Entity          : Line
Point 1 :
606086.809,230315.735,229.121;80,162;72,161
Point 2 :
606088.260,230314.768,229.199;116,161;103,158
Code :  110000
Type of Entity          : Line
Point 1 :
606088.260,230314.768,229.199;116,161;103,158
Point 2 :
606088.285,230314.553,228.629;116,179;99,176
Code :  110000
Type of Entity          : Line
Point 1 :
606088.285,230314.553,228.629;116,179;99,176
Point 2 :
606088.639,230313.012,228.493;95,190;74,186
Code :  110000
Type of Entity          : Line
Point 1 :
606088.305,230313.551,228.401;95,191;74,187
Point 2 :
606087.372,230313.238,228.456;40,191;28,190
Code :  110000
Type of Entity          : Line
Point 1 :
606084.060,230338.835,240.767;222,8;247,10
Point 2 :
606082.939,230341.538,228.221;222,156;251,154
Code :  110000
Type of Entity          : Line
Point 1 :
606082.322,230343.058,242.042;216,8;241,10
Point 2 :
606081.306,230344.497,227.980;215,156;244,154
Code :  110000
Type of Entity          : Line
Point 1 :
606082.335,230343.030,242.079;214,8;240,7
Point 2 :
606083.174,230338.325,228.385;211,155;240,153
Code :  110000
```

Appendix C(1). Results

```
============================
******** CFM_7_0.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 7
Image Sequence         : 0
Number of Entities     : 2
70005;-1;276,142;276,78~32;606078.7484,230338.5059,229.9476;606074.3861,230362.0939,245.3791
               71005,1,606078.7484,230338.5059,229.9476
               80011,0,606073.2534,230372.7646,229.6685
               81011,1,606075.6201,230357.8981,229.7574
70004;1;280,142;279,78~32;606079.2943,230339.3111,229.9902;606074.8581,230363.0308,245.5502
               71004,1,606079.2943,230339.3111,229.9902
               80010,0,606073.4130,230377.8909,229.7388
               81010,1,606076.0840,230360.2569,229.8093
============================
******** CFM_7_1.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 7
Image Sequence         : 1
Number of Entities     : 2
71005;-1;316,139;318,75~32;606078.7484,230338.5059,229.9476;606074.3861,230362.0939,245.3791
               70005,0,606078.7484,230338.5059,229.9476
               81011,1,606072.1711,230373.9048,229.7865
               80011,0,606103.4744,230208.2437,230.0016
71004;1;320,139;321,75~32;606079.2943,230339.3111,229.9902;606074.8581,230363.0308,245.5502
               70004,0,606079.2943,230339.3111,229.9902
               81010,1,606072.2585,230378.9135,229.8321
               80010,0,606106.9811,230185.7653,229.9971
============================
******** CFM_8_0.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 8
Image Sequence         : 0
Number of Entities     : 2
80011;-1;269,143;271,70~52;606078.9187,230342.4899,229.6079;606077.5330,230349.1452,243.0431
               81011,1,606078.9187,230342.4899,229.6079
               90017,0,606075.8199,230360.3101,228.9721
               91017,1,606076.5547,230355.5671,229.0924
               70005,0,606073.2534,230372.7646,229.6685
               71005,1,606103.4744,230208.2437,230.0016
80010;1;274,143;275,70~52;606079.5155,230343.4319,229.6534;606078.0656,230349.7571,243.1769
               81010,1,606079.5155,230343.4319,229.6534
               90016,0,606077.3723,230356.7970,229.0731
               91016,1,606077.7152,230354.0702,229.1604
               70004,0,606073.4130,230377.8909,229.7388
               71004,1,606106.9811,230185.7653,229.9971
============================
******** CFM_8_1.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 8
Image Sequence         : 1
Number of Entities     : 2
81011;-1;308,140;310,68~52;606078.9187,230342.4899,229.6079;606077.5330,230349.1452,243.0431
               80011,0,606078.9187,230342.4899,229.6079
               91017,1,606075.4643,230359.5282,229.1172
               90017,0,606092.8971,230279.4635,229.8987
               71005,1,606072.1711,230373.9048,229.7865
               70005,0,606075.6201,230357.8981,229.7574
81010;1;313,140;314,68~52;606079.5155,230343.4319,229.6534;606078.0656,230349.7571,243.1769
               80010,0,606079.5155,230343.4319,229.6534
               91016,1,606077.0406,230356.4890,229.1917
               90016,0,606092.8316,230280.1634,229.8962
               71004,1,606072.2585,230378.9135,229.8321
               70004,0,606076.0840,230360.2569,229.8093
============================
******** CFM_9_0.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 9
```

```
Image Sequence         : 0
Number of Entities     : 2
90017;-1;259,147;261,57~52;606079.8402,230342.5882,228.8505;606079.2558,230344.8600,242.1958
               91017,1,606079.8402,230342.5882,228.8505
               100023,0,606075.1120,230364.9418,228.0786
               101023,1,606077.2235,230354.8247,228.3865
               80011,0,606075.8199,230360.3101,228.9721
               81011,1,606092.8971,230279.4635,229.8987
90016;1;264,147;265,57~52;606080.3267,230343.3830,228.8767;606079.6617,230345.3884,242.3186
               91016,1,606080.3267,230343.3830,228.8767
               100022,0,606075.8230,230365.7534,228.1297
               101022,1,606077.8733,230355.4353,228.4245
               80010,0,606077.3723,230356.7970,229.0731
               81010,1,606092.8316,230280.1634,229.8962
============================
******** CFM_9_1.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 9
Image Sequence         : 1
Number of Entities     : 2
91017;-1;296,144;297,55~52;606079.8402,230342.5882,228.8505;606079.2558,230344.8600,242.1958
               90017,0,606079.8402,230342.5882,228.8505
               101023,1,606075.2219,230361.4869,228.3099
               100023,0,606082.8610,230332.5896,228.8778
               81011,1,606075.4643,230359.5282,229.1172
               80011,0,606076.5547,230355.5671,229.0924
91016;1;301,144;301,55~52;606080.3267,230343.3830,228.8767;606079.6617,230345.3884,242.3186
               90016,0,606080.3267,230343.3830,228.8767
               101022,1,606075.9215,230362.2178,228.3405
               100022,0,606086.0893,230321.3690,229.1564
               81010,1,606077.0406,230356.4890,229.1917
               80010,0,606077.7152,230354.0702,229.1604
============================
******** CFM_10_0.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 10
Image Sequence         : 0
Number of Entities     : 2
100023;-1;244,147;246,37~42;606080.9480,230342.1930,228.4798;606080.1073,230344.8909,241.8764
               101023,1,606080.9480,230342.1930,228.4798
               111032,1,606079.3014,230348.8635,227.8872
               90017,0,606075.1120,230364.9418,228.0786
               91017,1,606082.8610,230332.5896,228.8778
100022;1;250,147;250,37~42;606081.3990,230342.9553,228.5042;606079.6498,230348.4287,242.6654
               101022,1,606081.3990,230342.9553,228.5042
               111031,1,606080.0491,230348.7513,227.9397
               90016,0,606075.8230,230365.7534,228.1297
               91016,1,606086.0893,230321.3690,229.1564
============================
******** CFM_10_1.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 10
Image Sequence         : 1
Number of Entities     : 2
101023;-1;278,144;279,34~42;606080.9480,230342.1930,228.4798;606080.1073,230344.8909,241.8764
               100023,0,606080.9480,230342.1930,228.4798
               111032,1,606078.6325,230350.4875,227.9028
               91017,1,606075.2219,230361.4869,228.3099
               90017,0,606077.2235,230354.8247,228.3865
101022;1;284,144;284,34~42;606081.3990,230342.9553,228.5042;606079.6498,230348.4287,242.6654
               100022,0,606081.3990,230342.9553,228.5042
               111031,1,606079.5550,230349.9554,227.9646
               91016,1,606075.9215,230362.2178,228.3405
               90016,0,606077.8733,230355.4353,228.4245
============================
******** CFM_11_0.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 11
Image Sequence         : 0
Number of Entities     : 2
110032;-1;215,156;216,8~12;606082.3590,230340.7615,227.9410;606082.5189,230340.0961,240.3915
```

```
               111032,1,606082.3590,230340.7615,227.9410
110031;1;222,156;222,8~12;606082.7228,230341.3983,227.9461;606082.8497,230340.4500,240.5082
               111031,1,606082.7228,230341.3983,227.9461
============================
******** CFM_11_1.dat *********
Stereo Image File Name : C:\CFM\CFM.fit
Number of Pair         : 11
Image Sequence         : 1
Number of Entities     : 2
111032;-1;244,154;241,10~32;606082.3590,230340.7615,227.9410;606082.5189,230340.0961,240.3915
               110032,0,606082.3590,230340.7615,227.9410
               101023,1,606078.6325,230350.4875,227.9028
               100023,0,606079.3014,230348.8635,227.8872
111031;1;251,154;247,10~32;606082.7228,230341.3983,227.9461;606082.8497,230340.4500,240.5082
               110031,0,606082.7228,230341.3983,227.9461
               101022,1,606079.5550,230349.9554,227.9646
               100022,0,606080.0491,230348.7513,227.9397
```

Appendix D. Data structure and Classes

1. Struct for ground coordinates.

```
struct GrndCoord
{
	long ID;		// Line ID with matched
	int LorR;
	double x,y,z;
	struct GrndCoord *Next;
};
```

2. Class for one of stereo image and extracted lines

```
class IPoles
{

public:

	char StereoImageFile[_MAX_PATH];
	char DataFileName[_MAX_PATH];
	LINEDATA *ILinesD;
	LINEDATA *MLinesD;
	struct Point3D *ApproximateC;
	struct Point3D *TopEndC;
	int *PTStatus;
	struct GrndCoord **GC;
	long No;
	int	LorR;
	long ILine;
	camera_type Camera;
	int status;

// status = 0:			Read in OK
// status >= 1:  Not ready		4 is file open error

	void SetCoordMem();
	IPoles(char * DataFile, int flag);
	~IPoles();
	LINEDATA *GetILinesD(){return ILinesD;};
	LINEDATA *GetMLinesD(){return MLinesD;};
	void GetApproximate();
	void GetBackProjection(camera_type * cam);
};

void IPoles::SetCoordMem()			// Initialize coordinate memory block
{
	if( TopEndC == NULL )
		TopEndC = new struct Point3D[ILine];
	if( ApproximateC == NULL )
		ApproximateC = new struct Point3D[ILine];
	if( PTStatus == NULL )
		PTStatus = new int[ILine];
	if( GC == NULL )
	{
		GC = new struct GrndCoord * [ILine];
		int i;
		for(i=0;i<ILine;i++)
			GC[i] = NULL;
	}
}

IPoles::IPoles(char * DataFile, int flag)			// constructor of the IPoles  class
{
	FILE *fp;

	ILinesD = NULL;
	MLinesD = NULL;
```

```
ApproximateC = NULL;
PTStatus = NULL;
TopEndC = NULL;
GC = NULL;
ILine = 0;
char strTmp[256];
long ID,lID;
short C, x1, y1, x2, y2;
int Ps, Lr;
double Xg, Yg, Zg;
double Xg1, Yg1, Zg1;
double Xg2, Yg2, Zg2;
struct GrndCoord * TmpGC;

strcpy(DataFileName, DataFile);
fp = fopen(DataFile, "r");
if(fp == NULL)
{
        status |= 4;  // open file error
}
else
{
        fgets(strTmp, 256, fp);
        strcpy(StereoImageFile, GetValue(strTmp));
        fgets(strTmp, 256, fp);
        sscanf(GetValue(strTmp), "%ld", &No);
        fgets(strTmp, 256, fp);
        sscanf(GetValue(strTmp), "%d", &LorR);
        fgets(strTmp, 256, fp);
        sscanf(GetValue(strTmp), "%ld", &ILine);
        ILinesD = new struct LineData[ILine];
        SetCoordMem();
        if(ILinesD == NULL)
        {
                status |= 2;
                fclose(fp);
        }
        else
        {
                int i, j, Cn;
                char *pStr;

                for(i=0;i<ILine;i++)
                {
                        Ps = 0;
                        fgets(strTmp, 256, fp);
                        pStr = strchr(strTmp, '~');
                        if(pStr)
                        {
                                pStr = strchr(pStr, ';');
                                if(pStr != NULL)
                                {
                                        *pStr = '\0';
                                        pStr++;
                                }
                                sscanf(strTmp, "%ld;%d;%d,%d;%d,%d~%d",
                                        &ID, &C, &x1, &y1, &x2,      &y2,
                                        &Ps);
                                Cn = Ps / 10;
                                Ps -= Cn * 10;
                                if(pStr == NULL) Ps = 0;
                                if(Ps > 0)
                                        sscanf(pStr, "%lf,%lf,%lf;%lf,%lf,%lf",
                                                        &Xg1, &Yg1, &Zg1,
                                                        &Xg2, &Yg2, &Zg2);
                                if(Cn > 0)
                                {
                                        if( GC[i] != NULL)
                                        {
                                                TmpGC = GC[i];
```

```
                        while(TmpGC->Next != NULL)
                            TmpGC = TmpGC->Next;
                    }
                    for(j=0;j<Cn;j++)
                    {
                        fscanf(fp, "%ld,%d,%lf,%lf,%lf\n",
                                &lID, &Lr,
                                &Xg, &Yg, &Zg
                            );
                        if( GC[i] == NULL)
                        {
                            GC[i] = new struct GrndCoord;
                            TmpGC = GC[i];
                            TmpGC->Next = NULL;
                        }
                        else
                        {
                            TmpGC->Next = new struct GrndCoord;
                            TmpGC = TmpGC->Next;
                            TmpGC->Next = NULL;
                        }
                        TmpGC->ID = lID;
                        TmpGC->LorR = Lr;
                        TmpGC->x = Xg;
                        TmpGC->y = Yg;
                        TmpGC->z = Zg;
                    }
                }
        }
        else
                sscanf(strTmp, "%ld;%d;%d,%d;%d,%d",
                    &ID, &C, &x1, &y1, &x2,     &y2);
        ILinesD[i].LineID = ID;
        PTStatus[i] = Ps;
        if(y1 > y2)
        {
                ILinesD[i].Bp.wx = x1;
                ILinesD[i].Bp.wy = y1;
                ILinesD[i].Ep.wx = x2;
                ILinesD[i].Ep.wy = y2;
                ILinesD[i].Code = C;
                if(Ps > 0)
                {
                    ApproximateC[i].x = Xg1;
                    ApproximateC[i].y = Yg1;
                    ApproximateC[i].z = Zg1;
                    TopEndC[i].x = Xg2;
                    TopEndC[i].y = Yg2;
                    TopEndC[i].z = Zg2;
                }
        }
        else
        {
                ILinesD[i].Bp.wx = x2;
                ILinesD[i].Bp.wy = y2;
                ILinesD[i].Ep.wx = x1;
                ILinesD[i].Ep.wy = y1;
                ILinesD[i].Code = -C;
                if(Ps > 0)
                {
                    ApproximateC[i].x = Xg2;
                    ApproximateC[i].y = Yg2;
                    ApproximateC[i].z = Zg2;
                    TopEndC[i].x = Xg1;
                    TopEndC[i].y = Yg1;
                    TopEndC[i].z = Zg1;
                }
        }
        ILinesD[i].Match = 0;
}
```

```
				fclose(fp);
				if(LPReadImage(StereoImageFile, No, LorR))
				{
					status |= 8;
				}
				memcpy(&Camera, &MarHeader.camera[LorR], sizeof(camera_type));
			}
		}
		status = 0;
}

IPoles::~IPoles()
{
		ILine = 0;
		if(ILin esD != NULL) delete [] ILinesD;
		if(MLinesD != NULL) delete [] MLinesD;
		if(ApproximateC != NULL) delete [] ApproximateC;
		if(TopEndC != NULL) delete [] TopEndC;
		if(PTStatus != NULL) delete [] PTStatus;

		struct GrndCoord * TmpGC;
		if( GC != NULL )
		{
			int i;
			for(i=0;i<ILine;i++)
			{
				if(GC[i] != NULL)
				{
					TmpGC = GC[i];
					while(TmpGC != NULL)
					{
						TmpGC = TmpGC->Next;
						delete TmpGC;
					}
				}
			}
			delete [] GC;
		}
}

void IPoles::GetApproximate()
{
		int i;
		short x1,y1,x2,y2;

		if( ApproximateC == NULL )
			ApproximateC = new struct Point3D[ILine];
		if( PTStatus == NULL )
			PTStatus = new int[ILine];
		if (ApproximateC == NULL)
		{
			status |= 1;
		}
		else
		{
			for(i=0;i<ILine;i++)
			{
				if(PTStatus[i] == 2) continue;
				if(	ILinesD[i].Ep.wy > ILinesD[i].Bp.wy)
				{
					x1 = ILinesD[i].Ep.wx;
					y1 = ILinesD[i].Ep.wy;
					x2 = ILinesD[i].Bp.wx;
					y2 = ILinesD[i].Bp.wy;
				}
				else
				{
					x1 = ILinesD[i].Bp.wx;
					y1 = ILinesD[i].Bp.wy;
					x2 = ILinesD[i].Ep.wx;
```

```
                    y2 = ILinesD[i].Ep.wy;
                }
                GetApproximateCoord(x1, y1, x2, y2,
                    &ApproximateC[i].x,
                    &ApproximateC[i].y,
                    &ApproximateC[i].z,
                    Camera);
                TopEndC[i].x = ApproximateC[i].x;
                TopEndC[i].y = ApproximateC[i].y;
                TopEndC[i].z = ApproximateC[i].z + Cy linder.Length;
                PTStatus[i] = 1;
            }
        }
}

void IPoles::GetBackProjection(camera_type * cam)
{
        int i;
        MLinesD = new struct LineData[ILine];

        if (MLinesD == NULL)
        {
            status |= 1;
        }
        else
        {
            struct ImagePos Ic;
            struct Point3D pt;
            for(i=0; i<ILine; i++)
            {
                pt = ApproximateC[i];
                BackProject(cam, &pt, &Ic);
                MLinesD[i].Bp.wx = Ic.wx;
                MLinesD[i].Bp.wy = Ic.wy;
                if(PTStatus[i] == 2)
                    pt = TopEndC[i];
                else
                    pt.z += Cylinder.Length;
                BackProject(cam, &pt, &Ic);
                MLinesD[i].Ep.wx = Ic.wx;
                MLinesD[i].Ep.wy = Ic.wy;
                if(     ILinesD[i].Ep.wy > ILinesD[i].Bp.wy)
                {
                    MLinesD[i].Code = - ILinesD[i].Code;
                }
                else
                {
                    MLinesD[i].Code = ILinesD[i].Code;
                }
                MLinesD[i].LineID = ILinesD[i].LineID;
                MLinesD[i].Match = ILinesD[i].Match;
            }
        }
};
```

3. Structure of camera external orient parameters

```
typedef struct      /* rotation matrix */
{
   double m11,m12,m13;
   double m21,m22,m23;
   double m31,m32,m33;

}  rotmat_type;

typedef struct      /* camera system from GPS/INS -- GEOFIT */
{
   double x,y,z;    /* perspective centre absolute position (m) */
```

```
    double sx,sy,sz;   /* perspective centre standard deviations */
    double w,p,k;      /* phi, omega, kappa orientiation (dec. deg) */
    double sw,sp,sk;   /* phi, omega, kappa standard deviations */
    double xo,yo;      /* principle point (pixels) */
    double f;          /* focal length (pixels) */
    double ky;         /* y scale (unitless) */
    double k1,k2,k3;   /* radial lens distortion parameters */
    double p1,p2;      /* de-centreing correction */

    rotmat_type m;

}    camera_type;

/* GEOFIT/VISAT structures */

typedef struct        /* structure for the header file of images */
{
        long row;           /* number of image rows ie. 480 */
        long col;           /* number of image columns ie. 640 */
        long pixel_type;    /* size of pixel (bits) ie. 8-bit, 16-bit, 24-bit */

        long image_numbers;  /* number of images in this file */
   long date;           /* YYMMDD - ie. 930513 */
        double t;           /* GPS time */
     char frame[10];    /* Coordinate frame (ie. 3TM, UTM, WGS84) */
        char person_name[40];
        char company_name[40];

}   header_type;

struct img_head
{
   header_type file_info;
        camera_type   camera[6];
   char    expand[474];
};

typedef struct img_head HEAD;
```