Transport and Main Roads

Mapping in a City Environment Using a Single Hand-Held Digital Camera

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Queensland Government

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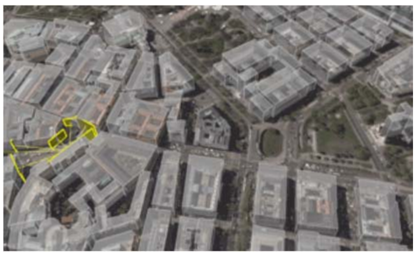
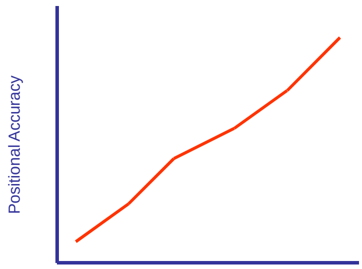
Purpose of the Presentation

The suitability and accuracy of a measuring technique based on a consumer grade digital camera and a conventional photogrammetry software is examined. The system is used to map public assets and points of interest located along the streets of urban environments where GPS positioning may not be available.



An Urban Environment

Accuracy Assessment



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Presentation Overview

Why inspect/measure public assets in an urban environment?

Limits of GPS technology

Mobile Mapping

Photogrammetry can map points of interest in GPS degraded areas

The camera and the photogrammetric software used in the tests

The test area

Marking, processing and computing the position of assets of interest

Camera trajectory reconstruction

Accuracy assessment

Presenting results

Examples of mapped assets

Summary, improvements and applications

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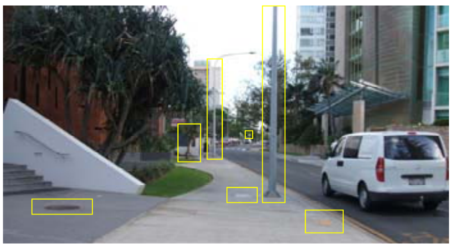
Why Inspect/Measure Public Assets in an Urban Environment?

Public assets such as roads, footpaths, public buildings, street lights, fences, trees, signs, electrical services require regular inspections in order to assess current conditions and functionality so as identify needed maintenance, replacement or improvement. This, in turn, gives an indication of public expenditure required for specific areas of a city.



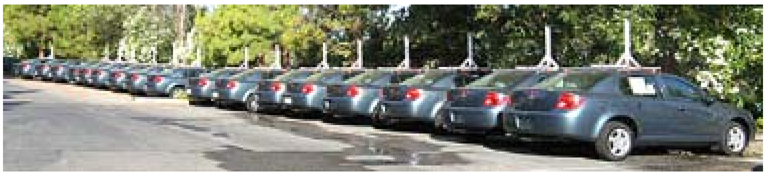
Mobile Mapping

Mobile mapping refers to the use of cutting-edge technology applied to meet the challenge of gathering and/or capturing constantly changing public assets data rapidly and precisely.

GPS Digital Cameras

GPS + 3D Compass + Laser + Camera

Vans



Google Street-View Camera Car Fleet - Each car is equipped with GPS and six stereo cameras taking images at 360^{0} every 2 metres.

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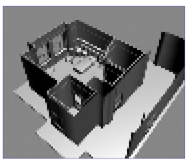
GPS is not Perfect: Mapping in GPS Degraded Areas

Under good satellite "visibility", GPS measurements are consistent in accuracy throughout a survey mission. However, such conditions may be disrupted when navigating or mapping assets in urban areas, indoor environments and densely forested areas. To overcome this drawback, inertial navigation systems, or INS, may be integrated or used in conjunction with GPS units (i.e., orthogonal gyroscopes, accelerometers, 3D compasses)…

Urban Areas

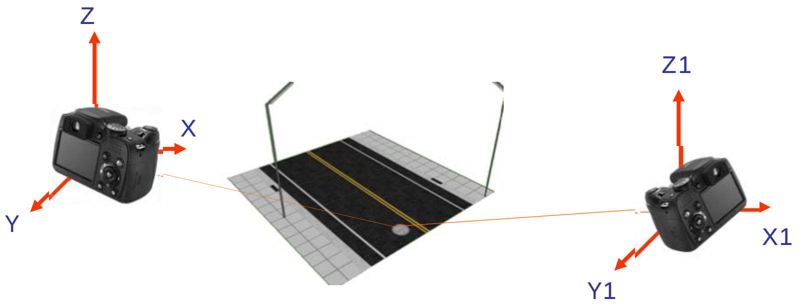


Indoor Environments

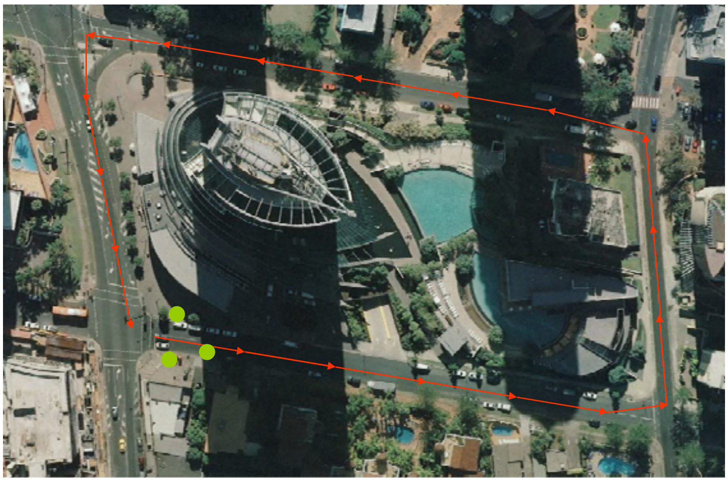
Densely Forested Areas

The Measuring Principle

The measuring system is based on the theory of photogrammetry, which consists of taking images of the same scene from different angles (stereo images). Photogrammetry allows for the measurement of multiple points of interest at a time with virtually no limit to the number of simultaneously triangulated or intersected points.



The Test Area



trajectory 50 m   Control points (x, y and z) established by a surveying total station

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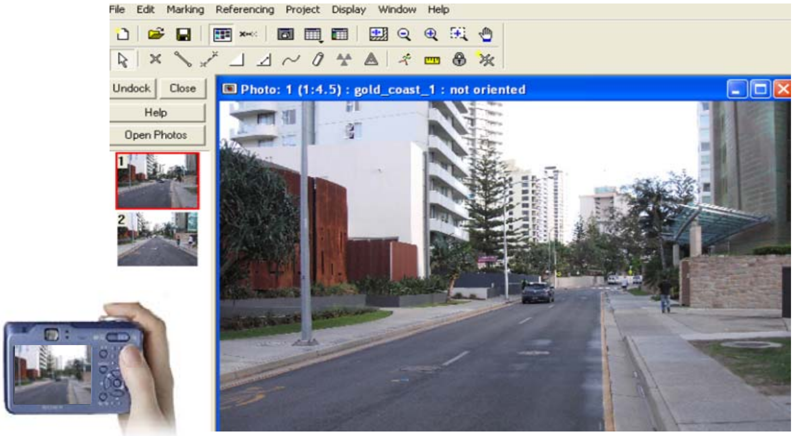
The Photogrammetric Software and the Digital Camera

Photomodeler includes: (1) handling of image display; (2) determination of orientation; (3) transformation of coordinates; (4) image processing functions; (5) measurement tools; and (6) ortho-image production and visualization. The **digital camera** used in this test was a 5 megapixel CCD consumer grade model.



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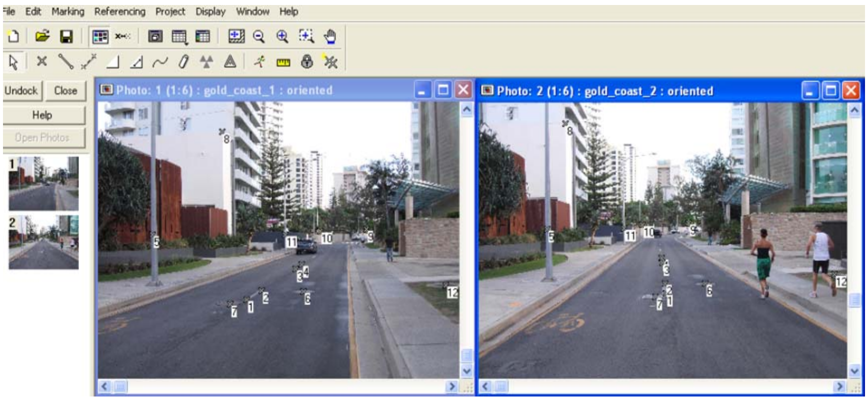
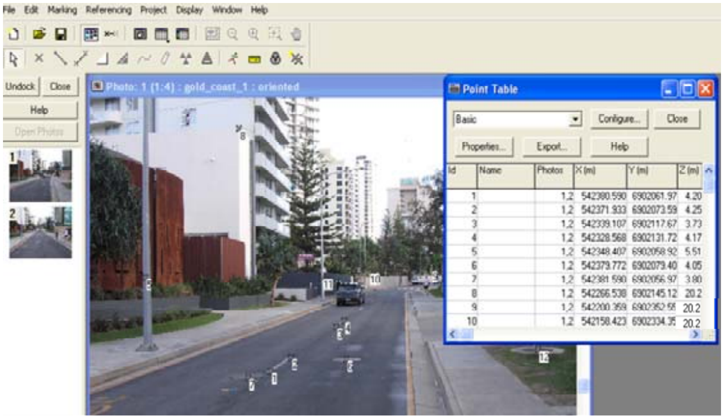
Marking the Target Points on the Stereo Images

After the photographs are loaded into Photomodeler, the photogrammetry analysis consists of “marking” points (i.e., natural or artificial targets) in the images. A procedure called “referencing” is then performed to match marked points between images; at least six identical points must appear in two separate images to perform this function.



Processing and Computing Coordinates

Processing is performed automatically after the minimum number of points in two separate images are referenced. In this step, PhotoModeler processes the camera calibration and the referencing data and creates spatial point coordinates (X, Y and Z). To provide real-world scale to the model, at least three initial control points (visible in the images) are input into the Photomodeler project.



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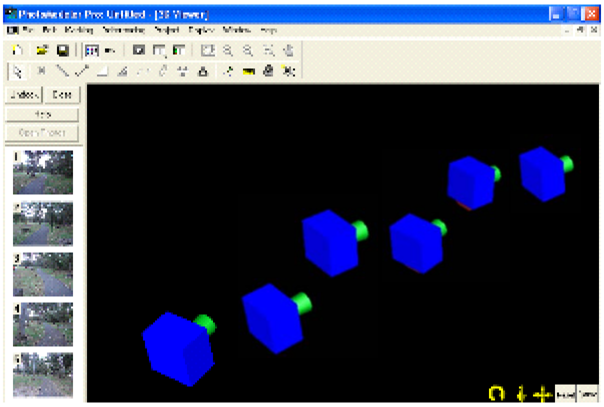
Camera Trajectory

Apart from computing the X, Y and Z coordinates of objects present in the images, Photomodeler can also determine the relative position of the cameras at the time of taking the photographs. This is particularly useful in recreating the time and position where the images were taken in sequence along a given street or path for extended periods without GPS signals.



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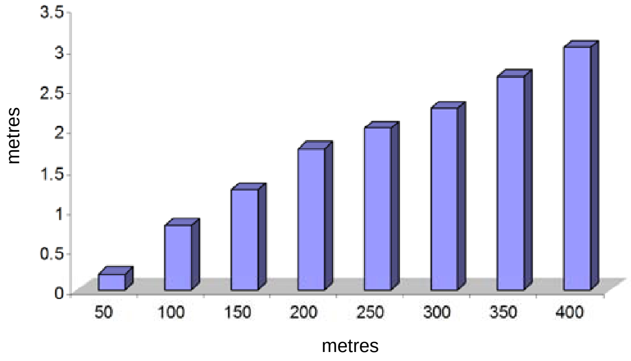
Accuracy Assessment

The graph summarizes the overall positional errors based on the differences of coordinates for 40 control points determined by a surveying total station and the same control points determined using the photogrammetric reconstruction.



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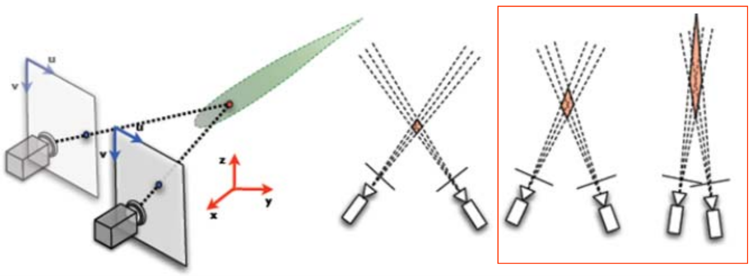
Achieving the Highest Accuracy

1. Ensure that a well-calibrated camera is used for the project
2. Maximize the number of photographs containing the same common point
3. Ensure that all points appear on three or more photographs
4. Ensure the camera positions as close to 90 degrees as possible
5. Make sure the project has at least 25 points and the photographs have good coverage
6. Ensure all points marked on the images are precise
7. Do not guess at a point location if it cannot be seen



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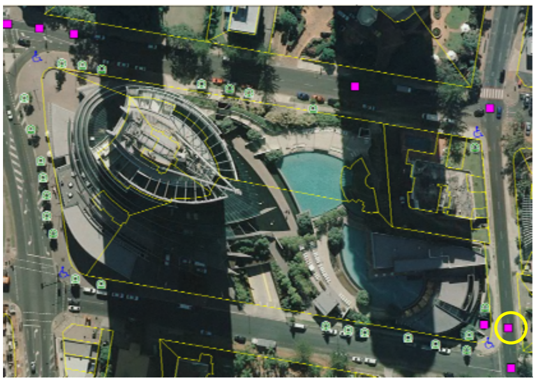
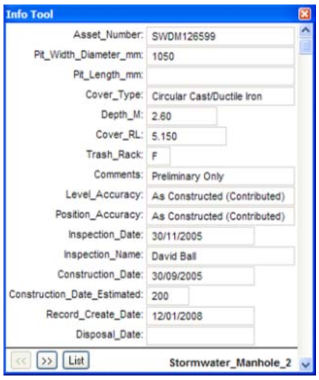
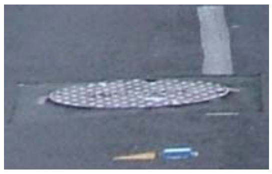
Presenting the Results



All captured assets were mapped using MapInfo.





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Examples of Mapped Assets

Corners of buildings

Footpaths

Trees

Lighting

Bins

Seats

SW and storm-water structures

Bus stops

Pedestrian crossings

Speed signs

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Mapping Summary

Number of images	*80*
Time required to take the images	*45 min*
Distance travelled	*450 m*
Overall cumulative accuracy	*+/- 3m*
Improved accuracy with additional 20 images taken in reverse order	*+/- 2 m*
Total number of assets captured	*150*
Processing time	*3 hours*

Note: Some preliminary planning consisting of a visual inspection of the area of interest was required prior to taking the images.

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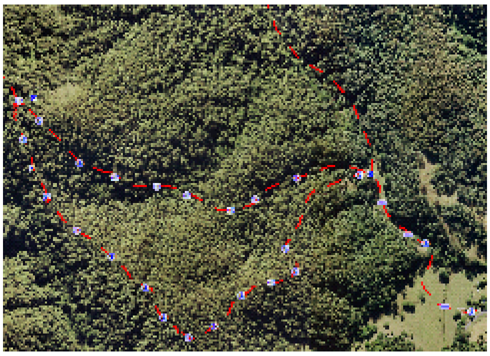
Application - Filling the Gaps in Densely Forested Areas



Fire Trails

- - - - - 100 m.

The user takes sequential pairs of images as he/she advances along a given path for extended periods without GPS signals. Each image is compared to previous images of the same scene taken from a previously occupied location. In this way, target points can be intersected and their X,Y and Z coordinates computed.

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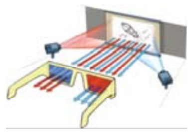
Future Improvements

Several external technology issues still challenge the general usage of the system presented here:

- Higher camera resolution + GPS capabilities
- Data transmission
- Improved processing time
- Improved memory storage
- Enhanced screen resolution
- Lower components cost
- Automation and ability to store attribute data



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