TELEPHOTOGRAMMETRY: PROVIDING PHOTOGRAMMETRIC SERVICES FOR MOBILE TELECOMMUNICATION USERS

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KEY WORDS: Photogrammetry, mobile mapping, multisensor system, GPS

ABSTRACT:

The purpose of this paper is to describe a research undertaken to develop a conceptual framework of telephotogrammetry based on concepts such as telegeoprocessing, mobile photogrammetry, geomobility and web services. In order to be operational, telephotogrammetry requires a combination of four different facilities: imaging, positioning, networking and computing. It consists of a hand-held mobile mapping system ready to acquire, visualize and to transfer spatial information through the web. The system includes also specialized servers communicating with the hand-held device and devoted to store the data and perform high intensive.

Based on a technological assessment, hardware component and software architecture were identified to fulfil the requirements for telephotogrammetry. Preliminary results show that hardware components are not entirely suitable. In particular, network performance is still a severe drawback for the transfer of information, i.e. image data. However software architecture is already available on the market and provides good perspectives in term of human-machine interaction and task automation.

1. INTRODUCTION

1.1 Background

The continuous development of mobile telecommunication systems provides large perspective in the field of ubiquitous computing, where information can be distributed to a large number of end-users anywhere at anytime. The ever increasing miniaturization of devices is also a reality that helps develop portable multi-sensor systems. Such a trend allows the development of mobile services of various kinds and in particular in the field of photogrammetry. In this context, telephotogrammetry is a new concept that aims to widely promote a range of services based on well-known photogrammetric techniques to specialized and non-specialized target users.

1.2 Motivations

The work about telephotogrammetry started with the idea to combine three components: a camera, a positioning system and a network interface on a hand-held device. Nowadays, technological advances allow to find commercial on the shelf and low-cost devices. Limitations in quality, precision and performance have still to be assessed and software architecture has to be developed in order to synchronize the functionalities of the three devices and harmonize the interaction with the user. Consequently telephotogrammetry was born so as to provide remote image processing services to such enhanced hand-held device.

There are several consequences of developing such a system. First it allows a greater harmonisation between field and office work as long as various users may access and process the same data through a dedicated telephotogrammetry service. The service is indeed distributed and may be accesses by several users in the same time. Then, it also allows direct field validation of processed data within some time delay, so as to reduce the time for field operation. Finally, access to photogrammetric processing is given not only to trained users but also to a wide public for specific applications.

1.3 Related work

The work involved here lays partly on the experience gained with mobile mapping systems since its first advent in early 1980s thanks to the public availability GPS signal. The current trend is about mobile telecommunication and the development of remote-driven applications supported on hand-held devices (Maguire, 2001; Grejner-Brezinska, 2004). Experiences are also carried out with low-cost systems, where lack of precision is put up with incorporation of external knowledge (Haala, 2003; Zlatanova, 2004). GPS receiver have gain tremendous advances by providing more compact devices and more efficient data collector (Wadhwani, 2001).

Another part of our work is strongly linked with the developments in the fields of digital photogrammetry and close-range photogrammetry. It is clear that more and more are these technologies made available to a wider audience of non specialized users (Fraser, 1997). Tools are simplified and already implemented on common Personal Computers for even low-accuracy applications. Also, digital photogrammetry is even advancing towards automation (Heuvel, 2002).

The idea of making available photogrammetric processing through telecommunication network was inspired by the initiative called telegeoprocessing or telegeomatic (Laurini, 2001). This initiative aims to provide GIS services the same way using telecommunication systems. Web photogrammetry is already nowadays a reality: ARPENTEUR is a good example of a web based interface for photogrammetric processing (Grussenmeyer, 2001). Additionally, mobile photogrammetry has been mentioned already in the literature (Fritsch, 2001), as a basis to develop e-buisness. Various services, called Location Based Service (LBS),.would be developed for mobile users, as for example a Virtual 3D service.

The last part of our work is related to 3D modelling and the management of 3D information obtained from photogrammetric processing. This is essentially based on 3D reconstruction methods from image sequences using computer vision techniques, like projective reconstruction and self-calibration. Important works and research were undertaken in this field (Faugeras, 1995; Debevec, 1996; Koch, 1999; Leymarie, 2000; Pollefeys, 2000). Web 3D applications, not only for visualisation but also for data entry, have been the subject of research (Zlatanova, 2000) using VRML as a basis. An example of implemention was done by Pharus s.r.l. (www.int3d.com). Concerning City models, they are being widely used in some European cities and some degree of automation has already been implemented (Förstner, 1999). City model building will certainly benefit from the development of telephotogrammetry.

The implementation of a photogrammetric service will further require the development of software architecture on the network. Web service developed for this purpose will help establish a communication pool in the network and deliver spatial data between various systems (Parsons, 2003).

2. CONCEPTION

This chapter will explain more in-depth the concept elaborated about telephotogrammetry.

2.1 System architecture

Telephotogrammetry relies first on a communication network used to exchange information (data) and to allow interaction between the user and the machine performing the processing (Figure 1).

The Mobile and Geographic Imager (Mobile GeoImager or MGI) has the task to acquire coordinate and image data and to synchronize them. The data are stored temporally locally but then transferred to the Processing Center (PC) using mobile communication and internet network. The PC receives and stores the acquired data in a Database Repository (DBrep) and wait for user commands to carry out given high computational intensive tasks.

One or several MGI may exist in the network, so that multi-user tasking is possible within a defined project. Tasking may also be triggered from an Office Computer (OC) when it cannot be efficiently done on outdoor conditions. In this context, the network has to support heterogeneous systems and a common language should be used to harmonize the work flow. Such an organisation has however the advantage to speed-up workflow.

2.2 Available functions

Data received from the MGI is processed according to the user commands. High computational processing will take place on the PC. Several levels of processing are identified:

1) No processing: the image is stored in the database
2) Mosaicing: sequence of images are combined together
3) Relative and absolute orientation: coordinates of camera point of view are retrieved.
4) Measurement: sequence of images is used to perform direct measurements
5) Modelling: sequence of images is used to build 3D models interactively
6) Texturing: texture extracted from images are applied to 3D surfaces
7) External texturing: Texture obtained for external data are applied to 3D surfaces
8) Precise orientation using textured 3D city model

2.3 Data visualisation

The data contained in the DPrep can be visualised on the MGI or on the OC. During visualisation the level of processing is taken into account and on-the-fly processing is performed using parameters from the processing stage. Various visualisation interfaces are used for either 2D or 3D data.

2.4 Virtual processing

The acquired data stored on the DBrep is not altered by the processing. Only the parameters computed to perform the process is recorded. This helps maintain data quality as best as possible and reduce the volume of data. When desired, function to bring data to production will be available.

3. IMPLEMENTATION

This chapter will bring more details about technological solution or solutions to satisfy the concepts described in the previous chapter.

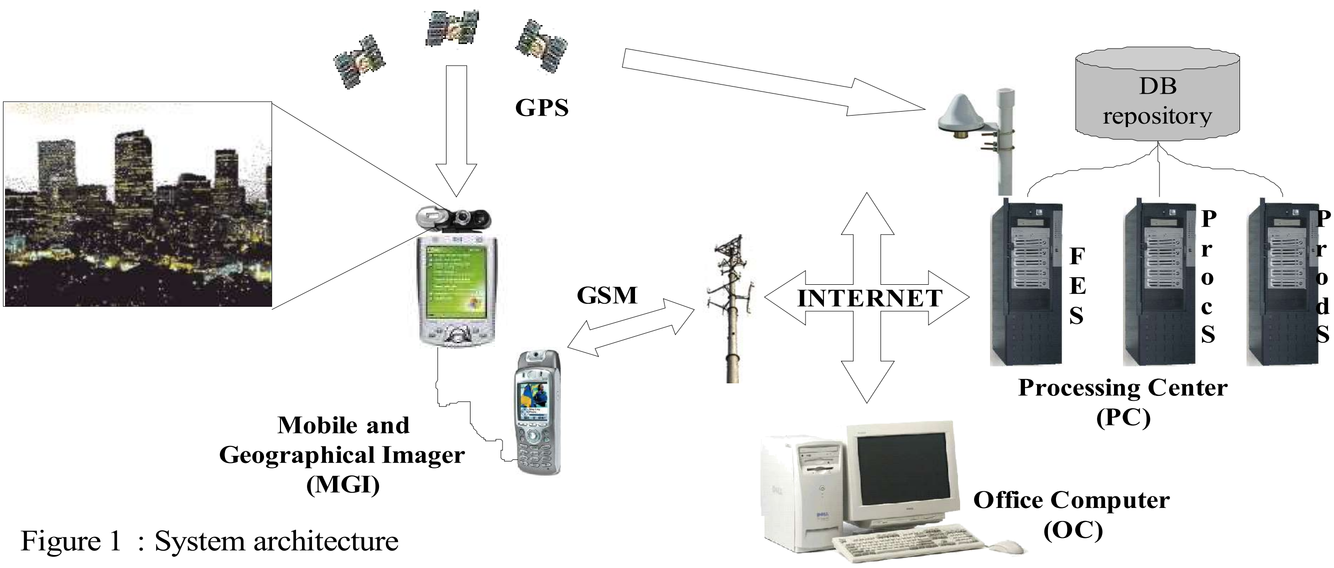


Figure 1 : System architecture

3.1 Hand-held device

The hand-held device is the main component of the telephotogrammetry system. It plays the role of the MI, a thin client that incorporates the following functions:

1) Image capture
2) Coordinate measurement
3) Temporary data storage
4) Network connection
5) Screen display
6) On-screen digitizing

On the market, no single device provides all of these functions. Considering the coordinate measurement function, two technologies exist: Global Positioning System (GPS) and mobile network positioning system. They greatly vary in terms of precision, cost and portability. Positioning information is not yet commonly available in mobile device. It needs further development and a public acceptance.

Considering the other functions, two types of device were identified: Smartphones and Personal Digital Assistant (PDA). Both of them provide computational power associated with a color screen, image capture and data storage. Networking possibilities and on-screen digitizing depends on models.
Three models were chosen for benchmarking:

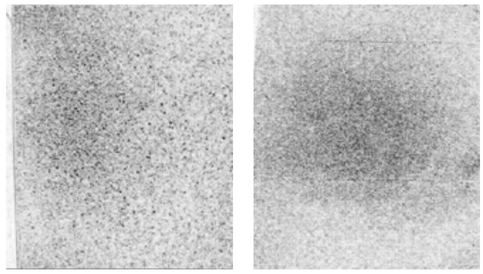
1) IPAQ H2210 with a camera module Flycam 1.3M (PDA)
2) Sony Ericsson P900 (Smartphone) with built-in camera
3) SPV 100 (Smartphone) with built-in camera

A comparison of the two model specifications is given in table 1. For the moment, the best solution is the IPAQ combined with a camera module. It is a real pocket computer, but only lacking of wireless connection. This is solved by using an additional mobile phone connected on the Bluetooth port.

Concerning image quality, provided capture software has systematic error in resampling and band alignment, so that pre-processing of image is required prior to compression. We also observed that image sharpness is not uniform and decreases towards on the edges of the image. Applying a edge filter on an image of a textured ground shows evidence of this fact (Figure 2).

3.2 Positioning technique

Nowadays, positioning technology is still under development. Specialized tools and services with high precision are readily available for professionals and emergence of non-specialized tools of lower accuracy is increasing. External low accuracy GPS modules, with Bluetooth or Compact Flash connectivity, are readily found on the market. For higher accuracy professional GPS antenna along with differential GPS (DGPS) or Real-Time Kinematic (RTK) functionalities is required.



2.5 m 4 m

Figure 2 : Sharpness assessment : Edge image of a textured ground. Dark areas are sharper than bright ones.

Post-processing of GPS signal is planned to be carried out at the PC (see Figure 1). Higher accuracy is reached using the RTK service provided by the Swiss Topographic Office, who is maintaining an automatic GPS network (AGNES). Precision range will reach between 0.01 to 0.5 meters.

GSM positioning is not yet widely available, but might provides close synergy with GPS when signal is of poor quality, like often in densely urbanized areas. Such Assisted Global Positioning System (A-GPS) opens wide perspective for an accurate, outdoor positioning system.

3.3 Data compression

Another weak link in the telephotogrammetry system is wireless network performance. Various technologies were developed to transfer data. Table 2 shows the data rate for each (see acronym paragraph) and the time required to transfer 1 Mbytes of data.

Mode	GSM	HSCSD	GPRS	EDGE	UMTS
Data rate	9.6 kb/s	14kb/s	<114kb /s	384kb/s	2Mb/s
1 MB	13 min	9.5min	1.2 min	21 sec	4 sec

Table 2: Wireless Network performance

Transfer of images requires a high data rate which is not yet available in mobile communication systems. So it is needed to reduce as much as possible the size of data transmitted by using compression techniques. JPEG 2000 file format is a newly widely used compression standard that preserves visual aspect of

	IPAQ+Flycam	P900	SPV 100
CPU	Intel XScale 400mhz	ARM 9 156mhz	120mhz TI OMAP ARM
ROM	32 MB	-	
RAM	64 MB	48 MB	16 MB
OS	Pocket PC	Symbian OS 7.0	Smartphone 2002
Storage	SD card, Compact Flash	Memory Stick Duo	SD card
Image resolution	1024x1280	640x480	640x480
Network	Bluetooth, infrared, USB	Bluetooth, infrared, GPRS, GSM, USB	Infrared, GPRS, GSM, USB
Screen size	240x320	208x320	176x220
java support	yes	yes	yes
Touch-screen	yes	yes	no

Table 1: Comparison of specifications for benchmarked hand-held devices

the image using wavelet transform technique. It allows a higher lossy compression rate compared to other compression algorithms while preserving image quality (Santa-Cruz, 2000). Implementation of JPEG2000 compression on the hand-held device requires sufficient CPU because intensive computation is performed.

3.4 Processing Center

The PC comprises of three units used in a client-server organisation. One is devoted to interact with the MGI or the OC and is call the front-end server (FES). The second one, the processing server (ProcS), will perform high intensive processing tasks of image processing and is built on powerful hardware components. The third one, the production server (ProdS), will perform production tasks in order to make available the results to the Internet community. All of the units are linked to a single database DBrep containing acquired images and corresponding processing parameters. Communication between the stations is based on common web service protocols using SOAP messages.

3.5 Human-machine interaction

One of the key point of the system is the semi-automation of the functions as, in the field of photogrammetry, it is still uncertain to automate all the processes. So an efficient human-machine interaction should be realized for the visualisation of either 2D or 3D information through Internet.

Nowadays two multi-platform technologies supporting 2D data are identified: Java and PHP. Both allow to build dynamic user interfaces linked with image server. The following two implementations exist but still require assessment and comparison:

1) Timemap: http://www.timemap.net
2) Mapserver: http://mapserver.gis.umn.edu

Concerning the visualisation of 3D data, more intensive processing will be required on client side. So it is not likely that this will be available on the MI. Only OC will efficiently be used to manipulate 3D data. However 3D visualisation on PDA is possible using VRML tool (see Cortona: www.parallelgraphics.com) but, due to the reduce size of the screen and the low CPU performance, this is not fully efficient for complex textured model.

3.6 Quality requirements

Quality requirement of the telephotogrammetry system is adjustable and will depend on the device preparation by the user. Quality is improved by performing the optional tasks described in Table 3.

Image quality	Lens calibration
	Colour calibration
	Band alignment
	Resampling enhancement
Positional precision	GPS measurement post-processing

Table 3: Tasks to improve system quality

4. USE CASES

In this chapter, the reader will find a description of various use cases of telephotogrammetry.

4.1 Image mosaicking

One of the basic processing levels is the mosaicking of sequence of images. It aims to combine images in order to obtain a uniform view of the scene. Such a process alters the geometry and the radiometry of the images.
An alternate goal is to improve the resolution by incorporating a number of overlapping images of the same scene, a process often called “super-resolution” in the literature. During the resampling process, it results in a finer grid size.

4.2 Remote measurement

Once orientation of a sequence of images is performed, the metric of the scene may be reconstructed, thus enabling direct distance measurement on images. Relative or absolute distances may be obtained according to the use or not of GPS data.

4.3 Rapid scene mapping

Simultaneous collection of images and positioning coordinates opens wide applications for the purpose of rapid scene mapping in case of crime, accident or even disaster (Gibson, 2000). It seems important to quickly collect georeferenced terrestrial image as a reference and as a basis for further 3D modelling. Reference image may be distributed to different entities in order to document real circumstances. 3d model may help understand the causes for the event to occur.

4.4 3d modelling

3D modelling of real object may be done based on a sequence of oriented images. This task is quickly implemented because of the availability georeferenced terrestrial images. Modelling is commonly done manually by visual interpretation. This provides large perspective in the field of architecture.

4.5 Build image database

Taking advantage of simultaneous acquisition of image and coordinates enables to build image database and subsequently allows to query images from de database. This is especially an application field for non-specialized end users.

4.6 City model building

Simplified acquisition of 3D model in mass using telephotogrammetry system might lead to the possibility to generate city models at a lower cost and shorter time.

4.7 Landscape assessment

Another field of application is the assessment of landscape. We consider here either urban or natural landscape, and its change through different time-scales: monthly, seasonal and finally yearly. This is a further enhancement of 3D city model, in which we include not only the natural environment but also its dynamic through time.

5. CONCLUSION

The general framework for telephotogrammetry as described here opens wide perspectives as to the exploitation of geo referenced terrestrial images. It is expected that such a tool will promote the use and exchange of 3D information and further stimulate the development of location based services and other applications like navigation based on three-dimensional city models or mobile augmented reality.

Telephotogrammetry lies on a system architecture establishing a close link between a hand-held device, the Mobile and Geographical Imager, and a Processing Center specialized in post-processing of acquired images and coordinates.

Requirements for software and hardware were studied. Nowadays, it is possible to find commercial on the shelf devices that provide functionalities required by telephotogrammetry services. Personal Digital Assistant or smartphones associated with positioning, imaging and networking equipment can be mentioned. However, no single integrated tool exists and software development compatible for specific platform is required. Moreover several limitations still impedes on the development of such services. Imaging sensors require higher resolution; positioning sensors a better positional accuracy along with higher miniaturization; networking devices a faster data transmission; storage devices a higher capacity and visualization devices a faster 3D engine.

6. ACRONYMS

GSM: Global System for Mobile telecommunication
GPRS: General Packet Radio System
HSCSD: High Speed Circuit Switched Data
EGDE: Enhanced Data GSM Environment
UMTS: Universal Mobile Telecommunication System
JPEG: Joint Photographic Experts Group
VRML: Virtual Reality Modelling Language
SOAP: Simple Object Access Protocol (XML protocol)

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