DEVELOPING A NAVIGATION SYSTEM TO PROVIDE A ROBUST REAL TIME POSITIONING FOR MOBILE MAPPING APPLICATION

Amir Saeed HOMAINEJAD

Independent Research Group on Geo-Spatial, Tehran, IRAN - s_homain@yahoo.com

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ABSTRACT:

This is a report on recent development of a navigation system, which is used to provide real time positioning for a mobile mapping application. The developed method is very unique and distinguished from other similar methods. An approach was designed based on Mobile Mapping Application in order to monitor a terrain in purpose to detect an unknown object inside the terrain. Once an unknown object was detected, position of the object was defined, and a dynamic platform was dispatched towards the object. The dynamic platform was supplied with a vision for monitoring and navigation. A number of targets were designed and set up around the terrain. The vision is continuously searching the targets. Once the target was recognised by the vision, the distance to the target would be computed and according to the defined strategy the dynamic platform would be pursued its journey toward the final destination. A stationary vision was set up on the terrain due to assist, detect, and extract any unknown objects at the terrain. This vision was used for navigation and mapping as well. The idea behind the developing of this system was based on invention of a system, which was able to implement a number of defined activities under Mobile Mapping application in real time without any supervision.

1. INTRODUCTION

Introduction of new techniques and sensors to photogrammetry at all, or to close range photogrammetry particularly, has given an opportunity to renovate the conventional methods of photogrammetry and create new methods. It is a great gratefulness to other groups of sciences for their inventions and researches, which cause to introduce a new era to photogrammetry. Whit utilising the application of new techniques, new terms have been materialized in photogrammetry. Terms of Machine Vision, Robot Vision, Videometric, Mobile Mapping, UAV, etc were unknown at late 1880s or early of 1990s, but with introduction of CCD camera, digital image processing, introduction of a range of sensors, techniques of remotely controlling a vehicle, and new inventions in electronic and computer, these terms have been gradually appeared in photogrammetry and attracted many interests.

With increasing of demands on utilizing vision systems for implementation of their applications on navigation, measurement, and assessment, makes an opportunity for photogrammetry to develop its capability in unconventional methods. Consequently, new methods are created in order to answer those demands; however, the new methods are involving new issues. Particularly, the new methods have to be assessed prior to implementation due to improving their reliability according to requested standards. Unfortunately, the new methods cannot be dealt like conventional methods, and for utilising of new method, it needs to develop a strategy regarding to methods of imagery.

Camera calibration is a critical process, which is constantly requested to improve the reliability of photogrammetry process and accuracy of outputs, and the mathematical modelling of camera calibration is based on collinearity equations. Collinearity equations have been developed based on this theory, which all rays emitted or reflected from an object are travelling in straight lines and will converge on the principle point of a camera and then they will diverge to make an image of the object on a plan behind the camera. Camera calibration for aerial photogrammetry and conventional photogrammetry can be fulfilled once prior or after of image acquiring. Aerial and conventional photogrammetry is using stereo imagery and the elevations of all images are roughly equal, once camera calibration's parameters were computed, they can be used for all images. In contrast, at non-conventional photogrammetry the distances of objects from camera are not equal, the depth of view is dramatically changing as well as baseline, and consequently camera calibration's parameters are changing from one image to another image. Therefore, it is very important to update all elements of camera calibration at the time of imagery. It is the most disadvantages for a close range photogrammetric project due to computing camera calibration in this quantity. In some cases self-calibration has been advised Fraser et al (1995), Fryer (1996), but self-calibration does not exclude this amount of calibration and the issue still remains. In some cases, pre-calibration and post-calibration have been recommended El-Hakim (1996), Shortis et al (1995), but this strategy includes some issues, which declines the reliability of whole process.

This paper is a report on developing a method of navigation based on Mobile Mapping at real time. A system consists of vision system, image processing, and server. Two vision systems have been employed; the first one has had stationary position, and the second one is set up on a dynamic platform. The stationary vision system is designed to monitor the terrain for detecting any object and navigation purpose. The second vision system is used for navigation. Images of the stationary vision are downloaded on a map of the terrain in order to position of and object on the terrain according to the map. Indeed, the map has been used for positioning of any object on the terrain. The map can be updated time by time, but not in a very large amount. Only limited information has been amended

to the map such as location of objects. This kind of information mostly related to GIS of terrain because only attributes of data are amended to the database.

The main distinguished characteristics of this approach are:
1. This approach is designed, as there is no requirement for camera calibration without sacrificing precision.
2. The designed navigation is independent from GPS and INS. Indeed this is a unique navigation method.

This method is independent from GPS and INS which most of the recent navigation systems are vastly using these systems. Instead, this method is compiling all images of a terrain to a map of the terrain (Homainejad 2007), which is already stored in the computer memory along a GIS of the terrain. An image of the terrain has been matched to the map so that each part of the image has been equivalent with its corresponding part on the map. Therefore, the coordinate of any part of the image can

be directly extracted from the map. The map of the terrain along a GIS was supplied in purpose to assist improving navigation and positioning. In addition, a number of targets were developed in order to improve navigation processing of dynamic platform. The vision was supplied for the dynamic platform, will search the targets in order to find the position and distance of the dynamic platform to the targets, in support of navigation. Once an unknown object is recognised on the terrain, the system will define position of the object according to the map and will consider a rout from the dynamic platform to the object, so called adopting a strategy, according to the GIS of the terrain, and then the strategy will transferred to the second part for implementation. Next chapters will be discussing the adopted method and strategy in details.
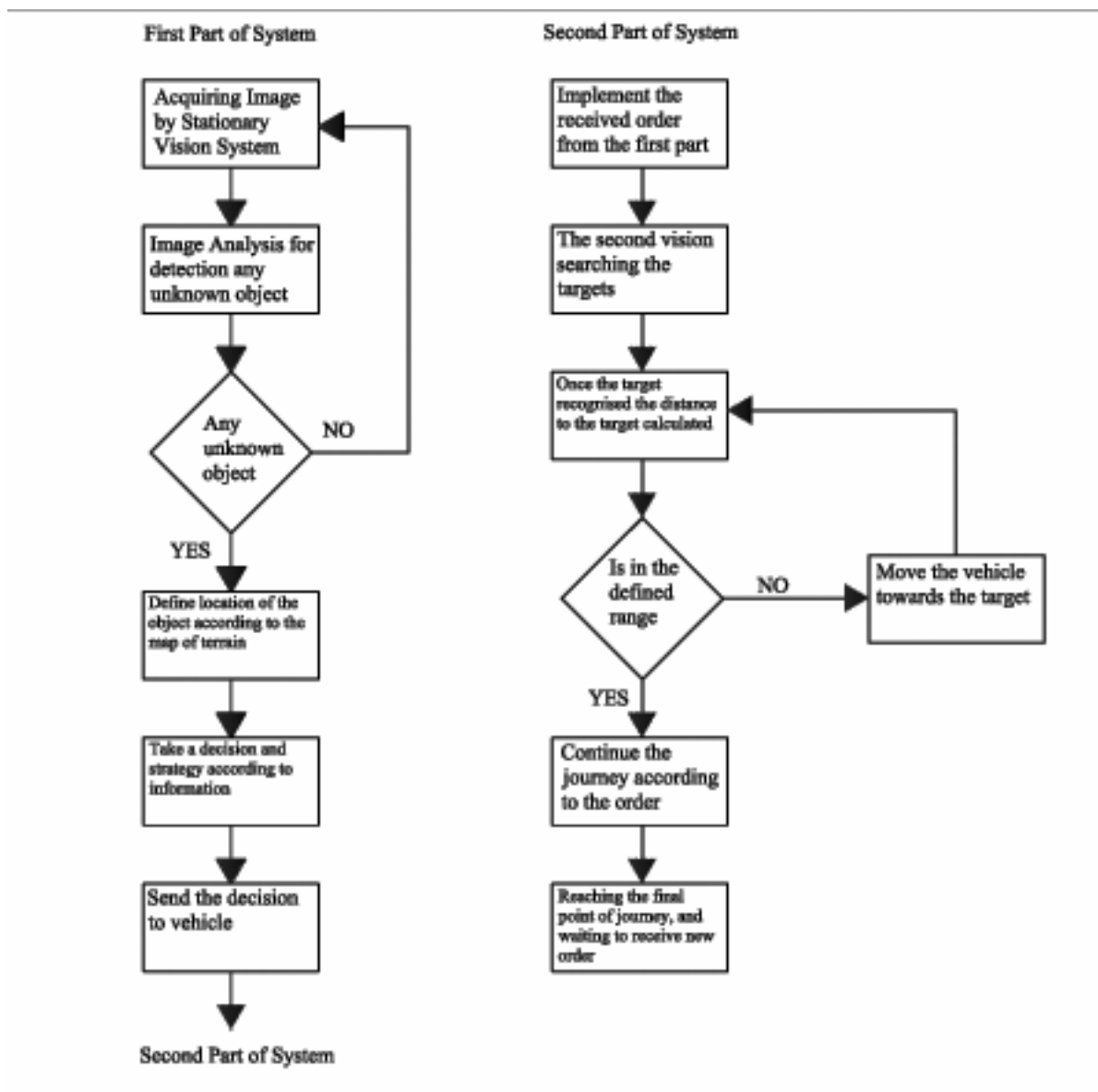

Figure 1. Demonstration of whole process of the system

2. SYSTEM'S ELEMENTS

The system consists of two parts. Each part works individually but an interface connects them. The first part consists of camera, image processing and analysis, section of data evaluation and providing strategy, and dispatch centre. Camera has stationary position and is set up without geometric restraint (Figure 2). Image processing and analysis is integrated due to detect and extract Geospatial data from images. The data evaluation and providing strategy section assesses received data regarding to a defined strategy and finalizes a strategy of processing to be carried out by the second part of this system. The dispatch centre, indeed, transfers the strategy to the second part of the system.

The second part, which is a dynamic platform, includes of vision, a computer so called Brain, and mechanical part. The vision is supplied for navigation, the brain is the centre of assessing and implementation of received information from the first part, and mechanical part is the motion compartment of the second part of the system. Next chapter will explain more about the system in details.

3. METHODOLOGY

Figure 1 is presenting a flow chart of the whole process of the system.

The core of the system mostly had emphasised on simplicity, robustness, and precision. The majority of similar systems are dependent to GPS and INS. However, GPS and INS are well known systems for navigation, but still there are a number of limitations for utilising of these systems. For example, there is limitation to use the GPS in indoor sites or even in outdoor sites under some circumstances, or INS includes some errors (Chiang et al 2004).

The navigation system is developed based on a geography and geometry presentation of a terrain. Two groups of stationary and non-stationary visions were utilised here. The stationary vision were utilised to monitoring constantly the whole of terrain in order to detect any unknown object. In addition, the stationary cameras are using to help navigation as well. As it was mentioned earlier, there is no requirement for camera calibration. Instead, A map of terrain and GIS of terrain were initially provided and stored in a defined memory. The aspect of implementation of a map and GIS of the terrain is that the acquired images can be replicated on the map in order to extract location of object according to the map. In addition, there is one more significant advantage of utilising a map and GIS of the terrain, which are distinguished this method. By utilising a map and GIS of terrain stationary cameras can be set up in any location without restraint. It means that the cameras can be set up in an unconventional way, like upside-down, very convergence, or upright position according to the terrain.

The non-stationary cameras are mounted on the dynamic platform, which in this study was a RC model car. These set of cameras are constantly acquiring images in order to search a particular targets, which are supplied and set up in a certain locations at the terrain. The purpose of the targets is to assist the navigation of the second part of the system.

All acquired images from cameras are converged in a computer was strengthen with pre-processing and post-processing softwares, which were specifically developed for this purpose.

The softwares are required to analyse the acquired images and implement the following steps:

1. To recognising and positioning any unknown object in the terrain.
2. To defining the best route between the dynamic platform and unknown object.
3. Dispatching the dynamic platform towards the unknown object.
4. Analysing the acquired images, from camera was mounted on the dynamic platform, for positioning and navigation.
5. And, to updating the GIS database.

The stationary vision has been set up in different locations. Acquired images from the stationary vision are transfer to the image processing section. At the image processing section, the images are analysed and interpreted in order to define an object. The method of object tracking, which was used by Homainejad (2007), has been adopted and implemented in this project. Once an unknown object has been detected, the acquired images are compiled on an existing map of the terrain due to define the location of the object according to the map. Then the extracted data are transferred to the next section for analysing and providing a strategy. The adopted strategy will be transferred to second part of the system. In this part, once the computer component or Brain receives the information from the first part of the system, will send a proper order to the mechanical part or the dynamic platform. The dynamic platform, which is the motion part of the second part of the system, moves towards the location according to the strategy. While the second part is moving, the vision component will acquire images in order to search supplied targes on the terrain. The targes are supplied on the terrain in order to facilitate the navigation processing. Once a targe has been recognised, the image-processing component will define the distance of the second part to the targe. The next motion of the second part is based on the distance of the second part to the target. If the second part is in a defined a distance from the target, the second part will be pursue according to the defined strategy.

4. ASSESSMENT OF THE SYSTEM AND CONCLUSION

Two groups of tests have been conducted. At the first group, all tests have been carried out with a stationary camera. The camera has been set up at several locations. Each time, the camera has had different situation, but camera has to be able to monitor whole part of the terrain. Once camera has had convergence position with the terrain, next time camera has had an upright position with the terrain, or camera has been set up in upside-down position. In each situation a number of tests has been conducted. In each test, the system has to recognise an unknown object at the terrain and dispatches the dynamic platform to the object. Each time, the system successfully recognised the unknown object at the correct location and dispatches the dynamic platform to the object and there was no a single failing. This group of tests proves the applicability and ability of the system while employed a GIS and a map of the terrain.

The second group of tests has been fulfilled in order to assess the ability of the system with stationary and non-stationary cameras. Similar the first group tests, the stationary vision recognised the unknown object and locates it. Then a strategy has been adopted. The strategy has been transferred to the second part of the system. Once the brain received the strategy,

would be sent the order to the mechanical compartment to approach the unknown object. The mechanical compartment moves towards the unknown object; meantime, non-stationary vision is searching the targes in order to calculate the distances between the second part and the targes. Once the target has been recognised and the distance has been calculated a new order will be transferred to the mechanical compartment. The new order is adopted based on the second part, which is moving in right route or it needs to give correction to the system, and possibly it needs to turn right or left at a certain distance according to the strategy.

A number of tests were fulfilled and all outcomes were precise and astonishing. The system significantly recognise an unknown vehicle in the terrain and dispatch a vehicle towards the location. There is no mistake by the system and all positions were defined precisely. The lack of mechanical performance of the mechanical part made a little bit issue, which was completely out of hand; however, by utilising the non-stationary cameras it was endeavoured to reduce this issue.

This is a unique system with a distinctive method, which distinguish the system from other similar system. The system is very precise and robust and can process in real time. Especially, the system has a lot of potentials, which can be utilised in a number of sites for enormous mobile Mapping applications.

This system can be utilised in indoor sites as well as outdoor sites. As another significant advantage of the system does independent from other positioning systems such as GPS and INS. The independency gives a unique characteristic to the system and distinguishes the system from other similar systems. This system can be implemented for multiple applications such as, civilian services, construction sites, confined spaces, and industrial sites.
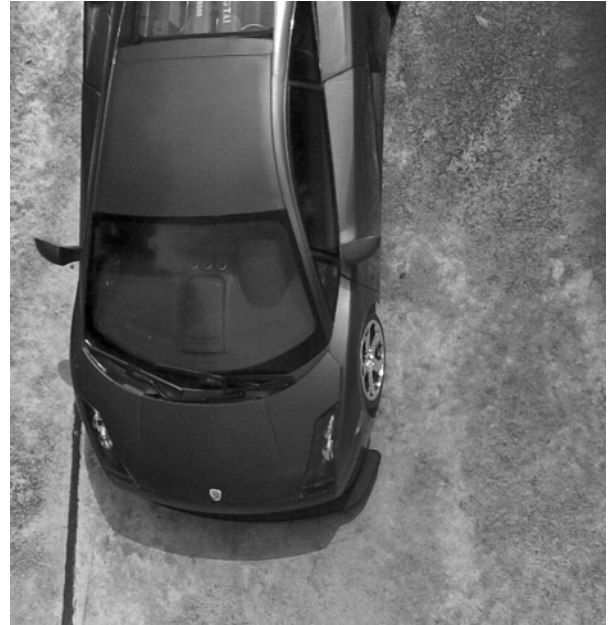

Figure 2. b: A typical Upright image

Figure 2. c: A typical Convergence image.

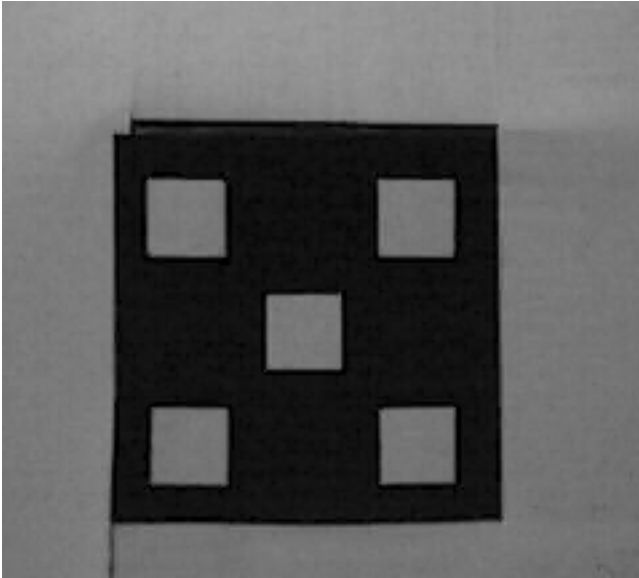Figure 2. a: A typical Convergence-Upside-down image.

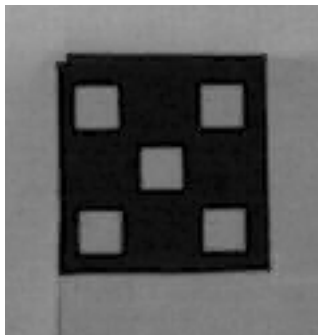Figure 3. a: View of the target at distance of 0.5 meter.

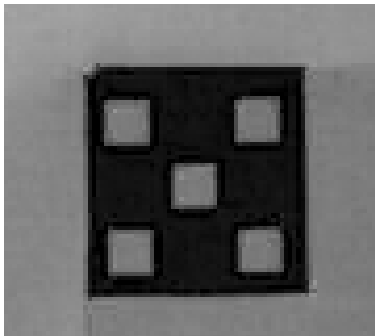Figure 3. b: View of the target at distance of 1 meter.

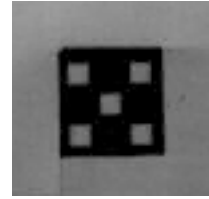Figure 3. c: View of the target at distance of 1.5 meters.

Figure 3. d: View of the target at distance of 2.0 meters.

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