Augmented Reality and Situation Awareness Applications for Military Computing

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***Abstract*—In this age of technology, the dependence on computers and other interfaces significantly increases, which requires them to be omnipresent. This requirement paved way for the development of a mobile handheld equipped with situation awareness methodology of the Location-Based Services and Global Position System. Based on the analysis of the smart-phone, an effective method has been identified for the real-time processing of geographic information acquired by a camera connected with a newly developed mobile application. By utilizing the proposed effective geographic information processing method, military computing technology can offer many opportunities, which trigger the thoughts and imaginations of people of all fields.**

***Index Terms*—military computing, augmented video stream framework, smart-phone, GPS**

I. Introduction

These days, military computing devices can perform many of the same computing tasks as smart-phones and laptop computers; however, in some cases, military technology can outperform smart-phone devices entirely. Military technology tends to be more sophisticated than smart-phone application technology on the market today because it can provide sensory and scanning features not typically seen in smart-phone and laptop devices, such as background-image and tracking of physiological function [1]. Also in investigation focuses on an extended form of mobile computing in which users employ many different mobile, stationary and embedded computers over the course of the day [2]. Situation awareness applications provide wireless information service that utilizes the location information of a mobile user. The convergence of multiple technologies including Internet, wireless communication, GIS (Global Information System), location determination, and portable devices has given rise to situation awareness applications. And military computing facilitates a new form of interaction between the human and the computer comprising a small body worn computer that is always accessible and ready for use [3]. To provide information based on the location of a mobile user, situation awareness applications require GIS functionality for mapping a user's current location and interest area through the wireless internet. This location information is acquired by location determination technology and the geographic information created with location information is represented on the screen of a portable device [4], [5].

In this paper, we propose to combine mobile geographic recognition with a GPS to map objects. With the help of man's ability to recognize the placement of objects and geographical relations between objects, location information given by a GPS is effectively enhanced. This method improves the quality of many military applications in smart-phone, wearable computers, etc. Among these are special operations, maintenance, communications, language translation, position determination, map functions, report preparation and calculations, training, security, medical support, logistics support, distance learning, imagery gathering, law enforcement, and reconnaissance. It should be noted that many of the advantages cited in individual sections apply throughout.

II. Applications

Table I shows the implication and uses of military computing technology have a widespread impact and influence the fields of wearable computing, smart-phone and augmented reality. The final aim of military computing technologies in each of these fields will be to efficiently incorporate functional, portable electronic and computers into individuals' daily lives.

TABLE I. Application of Military Computing

Application	***Product categories***
Augmented memory	The Remembrance Agents (RAs) are defense that continuously reminds the wearer of potentially relevant information based on the wearer's current physical and virtual context. RAs are always on and always active and working, instead of being 'worker up' when needed.
Repair Instruction	By putting as little as 3 exclusive marks at fixed distances from each other, a smart-phone camera with known focal length can recover the 3-D location of an object defined by these three marks. The military automatically determines the hazard, locates the 3D position of the object and prepares specific 3D real time step by step guidelines on the object for the technician to follow.
Navigation	Navigation 8 connecting a Global Positioning System (GPS) to military and certain mapping software allows the users to track their desired or the current location while exploring a new city. A visually impaired person might be able to receive warnings of approaching object and hence promote safety in their daily lives.

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Communication Management	A Wide Area Communication (WAC) can be used to manage personal communication naturally with much mobility. Speech recognition can be used to convert the user's responses (with constraints on vocabulary and grammar) into text for email responses. This, in turn, combines speech recognition, synthesis and digital audio recording to act as a virtual secretary which manages mobile communications.
Remote Sensing and Maintenance	Military can provide field workers by giving them remote assistance and expertise through digital data, audio and image. With this, even non expert maintenance personal can accomplish simple repairing tasks with aid of remote experts at the help desk.
Military	The potential applications of military computers to an infantryman were quickly recognized by organizations and other law agencies. Apart from providing command/control communication and navigation functions, a military could give access to tactical information that could help distinguishing between friendly and hostile forces, and potentially offering strategies for dealing with dangerous scenarios. Military computer will help infantryman use digitally distributed orders, maps, and intelligence. Wireless technology enables each soldier to communicate seamlessly with his comrades within a networked unit.

III. Overall System Concept

We propose a solution, which is completely dedicated to address the image extraction by optimising all the steps of the sensor integration, including hardware, data acquisition, and algorithmic processing. Situation awareness systems have been using image sequences for a long time since it is an essential part of the concept.

The image from the thing object or function of battlefield extraction in our approach, however, represents a much more forgiving task from the automated image processing view due to the special sensor arrangement the image scale changes are limited and the image contents are rather well defined. Traditional situation awareness systems work with forward or side-looking cameras, while our system uses a down-looking camera, with an image sensor plane almost parallel to the road surface. This way the image scale changes very slightly and there are an almost constant scale along the virtual object trajectory. To compensate for the smaller footprint, the image covers the road area of about that of a thing object; therefore, extracting features from a well-defined set of possible objects from almost constant scale imagery constitutes a much more formidable task compared to the generic situation awareness systems approach. Consequently, a large number of proven computer vision methods can be successfully applied for object extraction. Fig. 1 shows the generic model of the dedicated system concept. This is a GPS/INS integrated system [6], able to supply high-accuracy real time navigation data thanks to the aid of DGPS (Differential GPS), a second GPS antenna for high precision Azimuth detection and a 1024 pulses per revolution Distance Measuring Indicator (DMI). INS sensor has three Laser Gyros and three accelerometers. The core system is the LITTON LN-200 optic fibre gyro IMU. This is made of three accelerometers and three optic fiber gyros. It can supply 0.01° Pitch and Roll, and 0.04° true Heading accuracy in real time; 0.005 ° Pitch and Roll, and 0.02° true Heading accuracy after post-processing [7], [8].

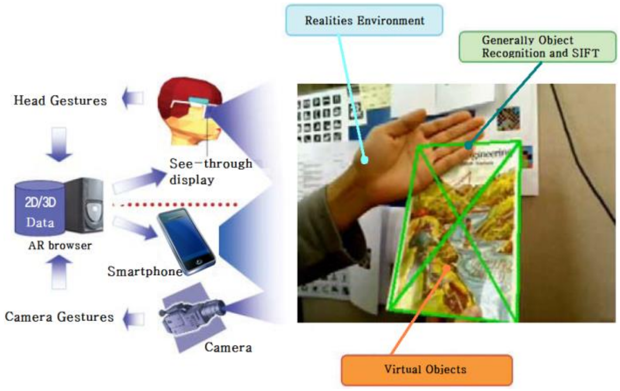

Figure 1. A graphical explanation of overall system design.

IV. Methodological Approach

To attain the aims and objectives of this paper we designed an application for monitoring emergency disaster notification data, integrating web service, wireless enabled web, internet GIS and smart-phone application service.

A. Performance of the Automated Object Video/Image Sequence Processing

To Assess the feasibility of automated line extraction with 3D positioning and consequently its real-time realization, a rich set of the potential video/image processing functions was developed in a Visual Embedded C++ programming environment [9], [10].

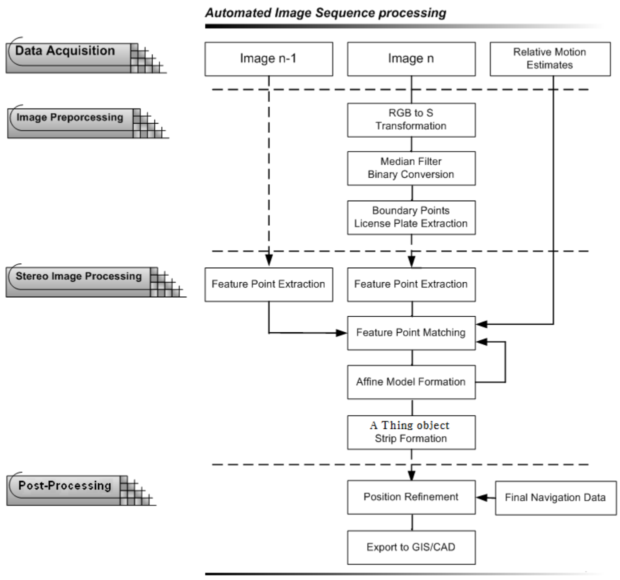

Figure 2. Workflow of real-time video/image sequence processing and post-processing.

This systems consists of several measuring devices (Video camera, gyroscope, GPS receivers, PDA etc.) mounted on vehicle or movement, and software that process the measuring results (Fig. 2). The system captures the visual road-condition state and thing object recognition with the video camera mounted on the vehicle or movement while it is moving along the road. The video represents a valuable source of data for road managers and road engineers since it provides visual feedback of the collected data.

The Augmented Video stream Framework (AVF) architecture (Fig. 3) is based on three components: Serialization Management, Presentation and search.

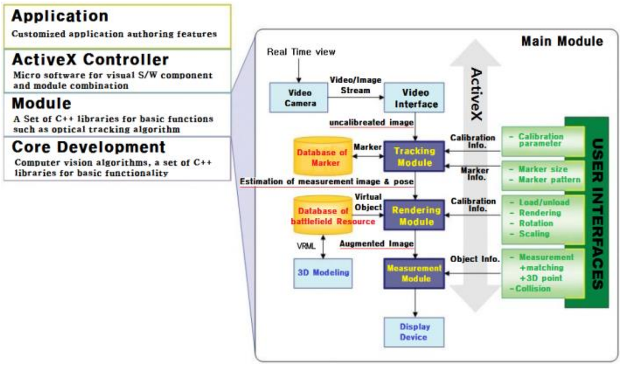

Figure 3. Workflow of real-time video/image sequence processing.

The Serialization Management is dedicated to: serialization/deserialization, access rights management, encryption and compression of augmented data. All of its functionality is realized as plug-in components enabling usage of arbitrary algorithms that are most suitable for concrete situation. As target/source for serialization/deserialization process the AVF supports Multimedia Container Format (MCF), URI or any database. The Presentation component provides synchronized playback of augmented video using commercial Multimedia Presentation Framework (MPF). Similar to the Serialization Management component, it supports arbitrary MPF which are implemented as plug-ins. The search component provides ability to search augmented data which is structured in object-oriented manner. The search component does not advocate any particular search algorithm. Thus AVF was implemented using Visual Embedded C++ programming language and the AVF implementation supports augmentation of AVI files, and uses Microsoft DirectShow for synchronized playback of video and augmented data. Compression and encryption of augmented data are realized using DEFLATE and RSA algorithms [11], respectively. The implemented search algorithm enables full properties and interval queries.

B. Design Steps for Detecting

The user can then associate the object data with another object data that is already stored in the system. These steps are show in Fig. 4. Two experiments were conducted to evaluate the cost of marking a map and the quality of a resulting map. A participant first made a STEP-I and then continued to work to make a STEP-II. The steps to make maps were as follows:

Uses GPS only is STEP-I. Each participant takes pictures of the 4 object (New Object, Target Object, Resulting mapping of objects, Relationship select button) by the digital camera and maps them by using GPS information only. This is comparable to a current most advanced system. And Uses GPS plus mobile geographic recognition is STEP-II. After the STEP-I steps, the each participant associates the objects with the target objects. First the participant draws a target object and stores it to the system. Then the participant picks up a target object from the list and selects the relationship with each object. This is the unique step of the proposed system.

- STEP-I: Uses GPS only.

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- STEP-II: Uses GPS plus smart-phone and desk-top geographic recognition.

After the STEP-I steps, the each participant associates the objects with the target objects. First the participant draws a target object and stores it to the system. Then the participant picks up a target object from the list and selects the relationship with each object. This is the unique step of the proposed system.

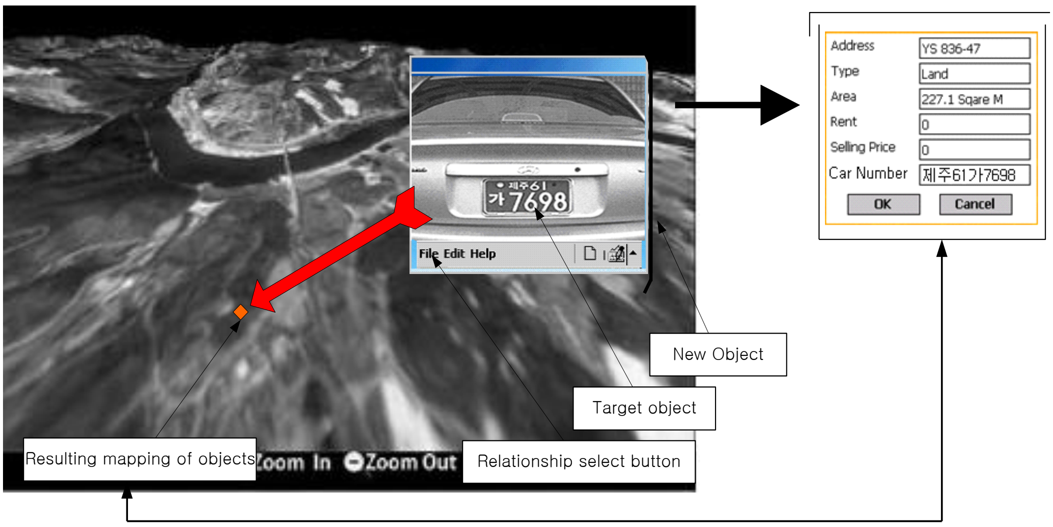

Figure 4. STEP-I: Design steps for detecting.

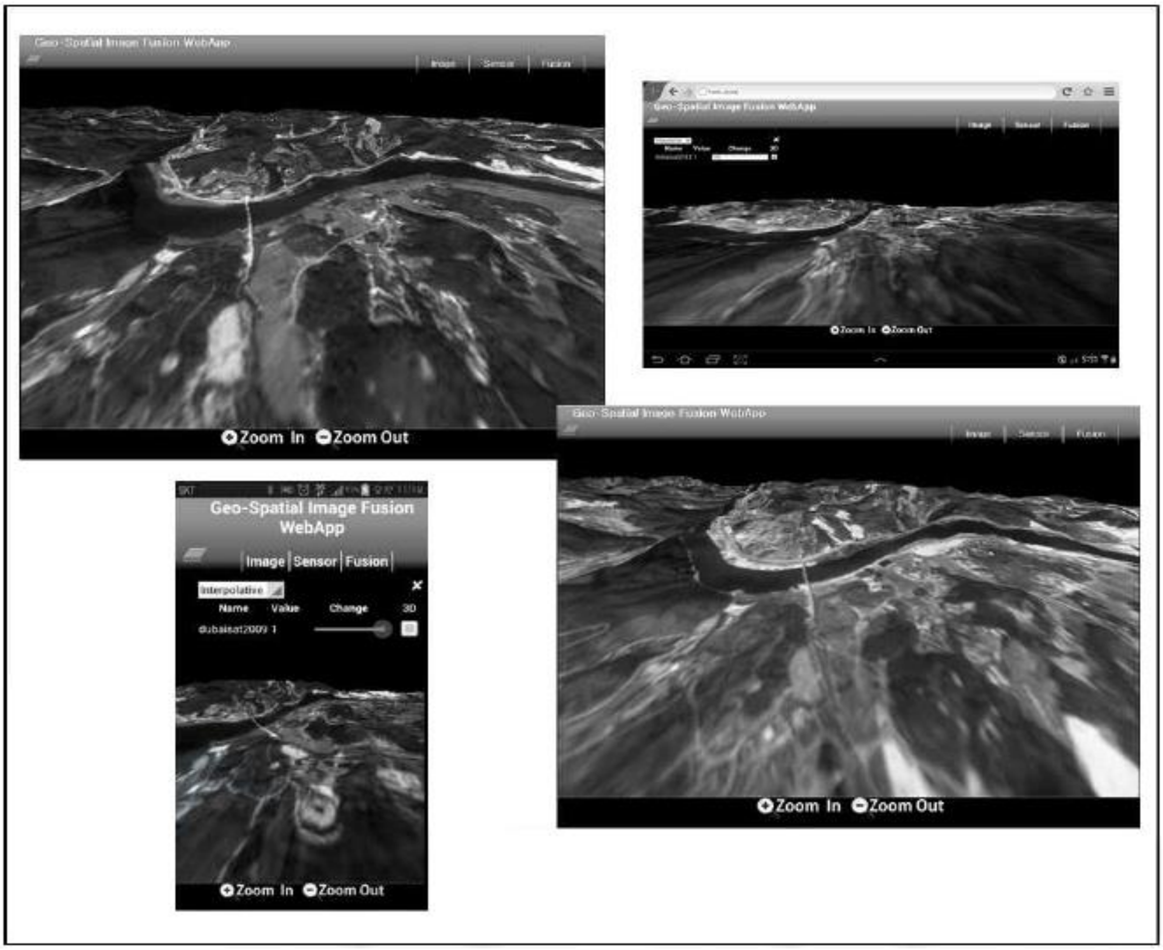

Figure 5. STEP-II: Optical image (Dubaisat-1) 3D multiple visualization of the desktop, smart-phone and tablet PC.

Figure 6. Implementation of augmented reality and situation awareness applications for military computing.

V. Experimental Results

The augmented reality and situation awareness applications for military computing system was used during the process of calculating the 3D spatial coordinates of the geography, which was then utilized for the listed items up until now. After normally running the equipment mounted on the mobile mapping vehicle, such as CCD cameras, GPS, IMU, etc., self-calibration procedures were performed in order to determine the interior orientation parameter and exterior orientation parameters of the CCD camera. The integrated results for GPS/INS were acquired for the filming time of the rectification target. The integrated GPS/INS results obtained like this are location and position information based on IMU and this performed integrated CCD/GPS/INS procedures that convert it to CCD camera lens-based elements. The various parameters found through these procedures were applied to all filmed images in order to interpret the actual geographies of the 3D spatial coordinates and the accuracy of this was analyzed, as shown in Fig. 5.

In this paper, possible applications were presented such as the efficiency of modify / updating scaled maps by using video / Image mobile systems and reduced time and expenses by improving the functions of road facility management systems and configuring a GIS DB. Furthermore, the VIDEO/IMAGE GIS concept, which is new geography information system utilizing video information, was established. This was configured to provide data for better decision-making methods by adding realistic visual information, compared to the existing 3D geography information system as seen in Fig. 6. We have presented an implementation of an embedded system for tracking the location of a moving object and for recognizing numbers on the military augmented modeling by a smart-phone device in wireless communication network and Internet. The video/image of the license plate is captured by the camera equipped in a military-grade smart-phone device. Then the image processing module in the proposed embedded system extracts the number information from the image data, using the spatial relative distance scheme. After this, the number and location information are encoded and transmitted to a remote sever. At the server, the digitized information is decoded and converted to a text format. Finally, it is sent to the end user by the server through a communication network.

VI. Conclusion

Recently, military computing focusing in future information-oriented, state-of-the-art and science & technology, is considering geospatial intelligence support ability to make it important part in the force development and future intelligence force generation, while wide-area Unmanned Aerial Vehicle (UAV), Synthetic Aperture Radar (SAR), Laser Imaging radar (LIDAR) and Ground Penetrating Radar (GPR) system is being introduced.

This paper has discussed the design and implementation of a mobile handheld for situation awareness system and modular mobile mapping. This mobile handheld targets military computing system application development, and focuses on modular mobile mapping as a core element of situation awareness system. Modular mobile mapping which support situation awareness system consists of the functionalities of location information processing, mobile embedded mapping, and mobile internet mapping which play a unique role in the military computing system application development. Modular mobile mapping becomes not only a core element of situation awareness system, but also a useful application for mobile GIS.

In this paper, we proposed to use Mobile geographic recognition in addition to a GPS for mapping objects. Location information by a GPS is effectively compensated and supplemented by Mobile geographic recognition of objects because these two have different characteristics. A mobile map-making learning system has been developed to utilize both types of location information. Making relationships between objects is common to organizing learning objects or knowledge objects. To support organizing knowledge in mobile learning, more consideration on relationships between objects will be needed. Adding collaborative learning feature to the system will also be our next step. Also, the lessons military computing gave future defense are First, need to establish geospatial intelligence (GEOINT) committee as a national level organization and participation of military. Secondly, establishment of doctrine customized in military computing environment. Third, development in equipment and technology to disseminate abundant GEOINT images (as it’s the fundamental factor). Lastly, requirement for education in basic course as well as specialized course at branch school. If the variety of ways is carried out actively, it can facilitate and realize national defense development.

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References

[1] S. Aninger and D. Hubner, “Dismounted soldier system and land warrior,” U.S. Army Soldier Systems Command, Public Affairs Office, Feb. 18, 1997.

[2] N. Adams, R. Gold, B. N. Schilit, M. Tso, and R. Want, “An infrared network for mobile computers,” in *Proc. USENIX Symposium on Mobile & Location-Independent Computing* Aug. 1993, pp. 41-52.

[3] I. Koeppel, “What are location services? – From a GIS perspective,” Technical Report of Sun Microsystems, 2002.

[4] L. Hecht, “Location services: Remarks, considerations, challenges,” in *Proc. First Location Interoperability Forum Meeting*, 2000.

[5] E. Beinat, “Location-Based services - Market and business drivers,” *Geoinformatics*, vol. 4, no. 3, Apr. 2001.

[6] T. Inoue, K. Nakazawa, Y. Yamamoto, H. Shigeno, and K. Okada, “Use of human geographic recognition to reduce GPS error in mobile map-making learning,” in *Proc. International Conference on Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies*, 2006, pp. 222-226.

[7] L. Qian, Y. Xin, *et al.*, “Rapid GIS database generation using GPS/INS controlled CCD camera,” in *Proc. Canadian Conference on GIS*, 1994, pp. 465-477.

[8] Y. Q. Chen and Y. C. Lee, *Geographical Data Acquisition*, Springer, 2001, pp. 200.

[9] A. Habib, “Matching road edges in stereo-image sequences using data association techniques,” *Photogrammetric Engineering and Remote Sensing*, vol. 66, no. 1, pp. 91-98, 2000.

[10] C. Toth and T. Schenk, “Feature-Based matching for automatic image registration,” *Instrumental Transcommunication Journal (ITC Journal)*, pp. 40-46. 2004.

[11] W. Diffie and M. Hellman, "New directions in cryptography," *IEEE Transaction on Information Theory*, vol. 22, pp. 644-654, Nov. 1976.

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