FEATURES OF THE EMBEDDED COMPUTER SYSTEMS FOR DATA ACQUISITION IN HUMANITARIAN DEMINING

ZNAČAJKE UGRAĐENIH RAČUNALNIH SUSTAVA ZA PRIKUPLJANJE PODATAKA U PROCESU HUMANITARNOG RAZMINIRANJA

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Abstract: *Using mobile embedded computer systems and mobile communication technologies in combination with GPS, database systems, GIS, and Internet based technologies can significantly improve overall control and data collection in demining process. Although new infrastructure and equipment is needed, benefits come out quickly in real-time supervision of the demining process, better QA, immediate equipment problems detection, and using collected and verified data in improving existing and developing new detection technologies. Final result is improved efficiency of overall demining process.*

Ključne riječi: humanitarno razminiranje, ugrađeni računalni sustavi, mobilni komunikacijski standardi, tehnologije temeljene na Internetu, baze podataka, analiza podataka

Sažetak: Upotreba mobilnih računalnih sustava i komunikacijskih tehnologija u kombinaciji sa GPS-om, bazom podataka, GIS-om i tehnologijama temeljenim na Internetu može značajno unaprijediti cjelokupnu kontrolu i prikupljanje podataka u procesu razminiranja. Iako je potrebna dodatna infrastruktura i oprema, to će se ubrzo pokazati korisnim kroz nadzor procesa razminiranja u stvarnom vremenu, bolji nadzor kvalitete (QA), trenutno otkrivanje probleme s opremom, te korištenjem prikupljenih i verificiranih podataka za poboljšanje postojećih i razvoj novih tehnologija otkrivanja mina. Konačan rezultat je poboljšana učinkovitost cjelokupnog procesa razminiranja.

1 INTRODUCTION

Currently, information management in the humanitarian demining process[1] is based on the off-line information input and processing. Existing information systems (IS) are oriented toward the overall management of the demining campaign[2]. Collected field data, reports and all other data are put into the information system (IS) manually and there is no direct data acquisition from the detecting equipment. This leads to inevitable delay from the moment when information was generated until the moment it enters the IS and becomes available.

Proposed integrated information processing solution consists of four interconnected layers. Outer layer is based on embedded microcontroller system built around the detection equipment, making possible real-time data acquisition of the detection data together with time and position information. Collected data are transferred to the Field unit, than to the Regional center, and finally to the State center at the inner layer. At each layer appropriate data processing, filtering and reporting is performed.

Advantages of the proposed system are numerous. Overall demining process can be supervised in real-time and quality control is easier and more exact. Information about area covered by the detector or demining machine is available immediately[3]. In unfortunate case of an accident, either during actual demining or later on cleared area, events that led to an accident could be accurately reconstructed. Using collected and verified data from previous detection, system can learn from experience and correct its classification skills during demining process, making continuous improvement of detection ability.

At the current level of demining technology, proposed system could be implemented on demining machines[3] and eventually metal detectors. Remotely controlled platforms became standard part of machines for mechanical demining. Monitoring and recording position of the detector or tool for mechanical demining could significantly improve safety and speed of demining operation. Information about covered area is immediately available. Additional cost of the differential GPS could be justified by using the position information for automatic guidance of the demining machine. Such a technology is readily available and is used e.g. for controlling the combine harvesters.

As new detection technologies will become available, they can be incorporated into the proposed system. E.g. detector based on combination of the metal detector and the ground penetrating radar (GPR) is one of the most promising recent developments.

2 SYSTEM ARCHITECTURE

Overall system architecture is shown in Fig. 1. Each deminer carries the Detector Module (DM), which acquires data about current position, time, and sensor probe response. All this data are sent to Field Unit Module (FUM) over the wireless media like IRDA, Bluetooth, Radio link or stored on the MMC (Multimedia Memory Card) media.

FUM can be located near deminers (at safety distance of at least 50m) or in the local area center. FUM stores all collected data from DM in local database system. FUM has communication equipment for sending sorted and packaged data over longer distances, via wireless network, e.g. GSM (WAP or GPRS) or via wired telecommunication network, for example with analog modem or digital teleequipment (e.g., PSTN or ISDN or ADSL). In case of GSM usage, communication depends on specialized gateways, which finally provide well known Internet and TCP-IP node.

Regional Center Subsystem consists of regional web server, regional database, and GIS (Geographic Information System) which stores all collected regional demining data, giving possibilities of the real-time coordination and supervision of the demining process.

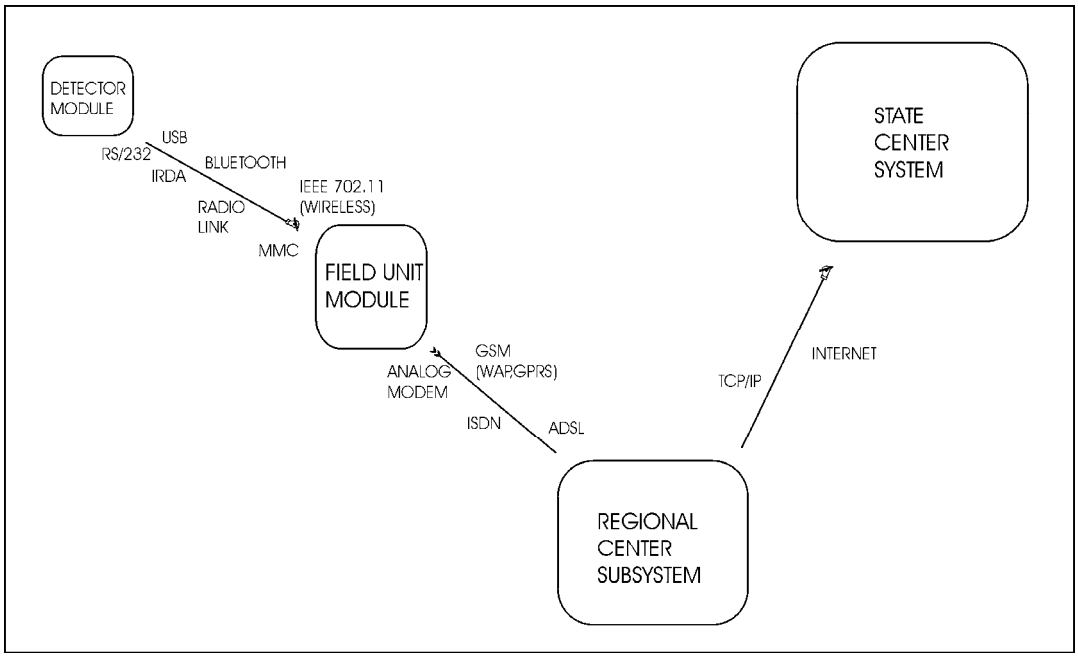

Figure 1. Overall System Architecture

Finally, there is the State Center System with main demining database and GIS, which incorporates all information about the overall demining process. Communication between Regional subsystems and State System is always over TCP/IP protocol.

2.1 Detector module

Detector module is shown in Fig. 2. It consists of the sensor probe, analog signal amplifier with A/D (Analog-To-Digital) converter encapsulated in converter module, digital signal processor (DSP) for data acquisition and processing, general-purpose microcontroller with user interface and Global Positioning System (GPS) module.

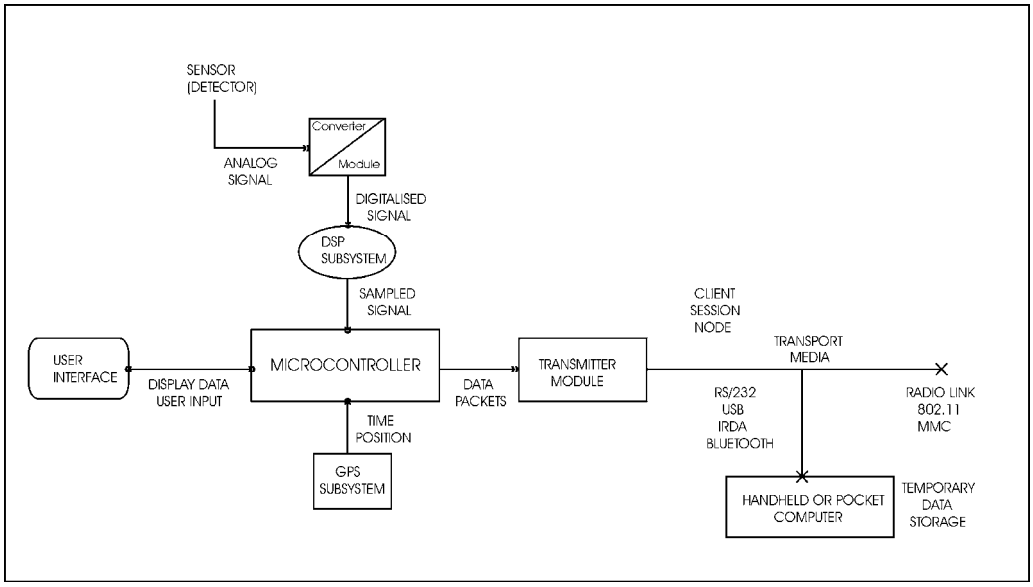

Figure 2. Detector Module

Sensor probe generates analog signal representing certain features of the examined area (e.g. metal content)[4]. That signal is amplified in Amplifier and digitized and sampled in A/D and DSP, which is also responsible for execution of advanced signal processing, classification and recognition algorithms. Microcontroller is central unit in Detector, which connects all other units. It can interface with many other digital electronic devices, making possible later upgrades and improvements. It can also communicate with other devices like PCs, mobile phones, handheld or GSM modules. Acquired data is formatted to proper packet frames and can be transmitted via different communication standards.

Through the user interface, deminer can adjust various detector parameters, like sensitivity. Task of the mine detection algorithm executed on DSP is to extract relevant features from the detector signal and perform pattern recognition to determine whether the examined spot contains landmine. Using collected and verified data from previous detection, system can learn from experience and correct its classification skills during demining process, making continuous improvement of detection ability.

GPS system acquires data about current position and time. Required position measurement accuracy, which should be in centimeter range, requires usage of differential GPS (DGPS) system. The position and the time stamps are attached to the data, which makes possible accurate reconstruction of the overall demining process – knowing "when" and "where" is extremely important for quality control, reconstruction of events that led to an accident etc.

Communication path is needed for data transfer from Detector Module to Field Unit Module. Few connection types are suitable for that case, and there are few approaches: to send data over short-distance communication links like Bluetooth, IRDA, RS-232 or USB to handheld or pocket computer which deminer carries with, to store acquired data onto MMC (Multimedia Memory Card) and copy them later, or to send data directly through embedded radio link controller or IEEE 802.11 standard. Typical transmitting data rates for immediate transfer are from 9800bps (radio link) to 2Mbps (IEEE 802.11), which depends on selected connection type.

2.2 Field unit module

Field Unit Module is shown in Fig. 3. It can be located close to deminers (at safety distance of at least 50m) or in local area center.

Field Unit Module consists of receiver module that supports one or more communication links and standards like Bluetooth, IRDA, MMC, IEEE 802.11, and radio link. It is based on standard x86 PC equipped with the transceiver module. FUM stores all collected data from Detector Modules in local database system, and groups data by the deminer and the equipment unique identification. In addition, it can locally archive data and help in supervisory and post-analysis, make reports about current demining phase etc. From this data, mine maps with labeled examined area borders can be constructed, so this information can be uploaded back to all Detector modules. Warning could be issued if person carrying the equipment comes close to the border of still contaminated area.

Field Unit Module has communication equipment for sending sorted and packaged data over longer distances, via wireless network, for example GSM (WAP or GPRS), or via wired telecommunication network, for example with analog modem or digital teleequipment (for example, ISDN, PTSN or ADSL). In case of GSM usage, communication with FUM over Internet depends on specialized gateways (GSM-to-TCP/IP).

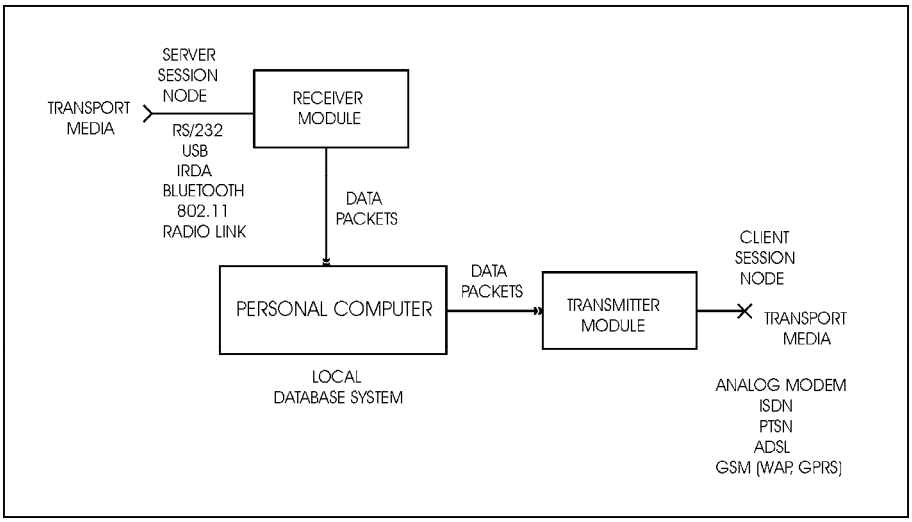

Figure 3. Field Unit Module

2.3 Regional center subsystem

Regional Center Subsystem (Fig. 4) consists of regional web server, regional database, and GIS, which stores all regional demining data, giving possibilities on regional coordination and supervisory over demining process.

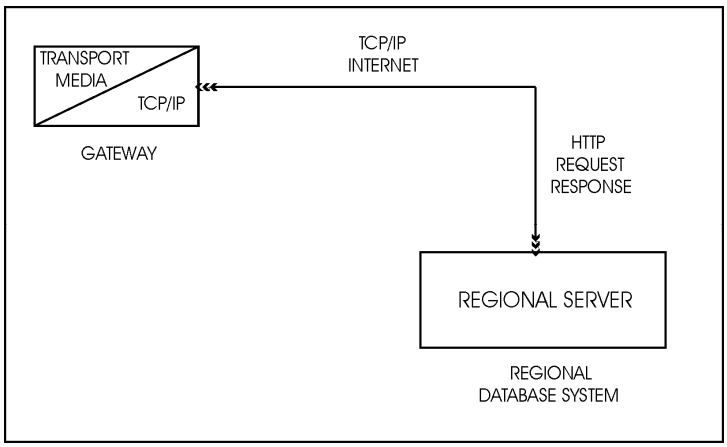

Figure 4. Regional Center

It continuously acquires and process data from all active field unit modules in the region, and send digested information to the state center.

2.4 State center system

State center is shown in Fig. 4. State Center System contains the main database and GIS, which incorporates all data and operations in demining process. Various reports could be generated, from particular detector performance to overall information about area cleared, number of mines found etc. In addition, content can be archived, which may be very useful later. For example, in case of future mine-accident, data can be extracted from archive, and determination of fault can be made.

Communication between Regional subsystems and State System is always via TCP/IP protocol.

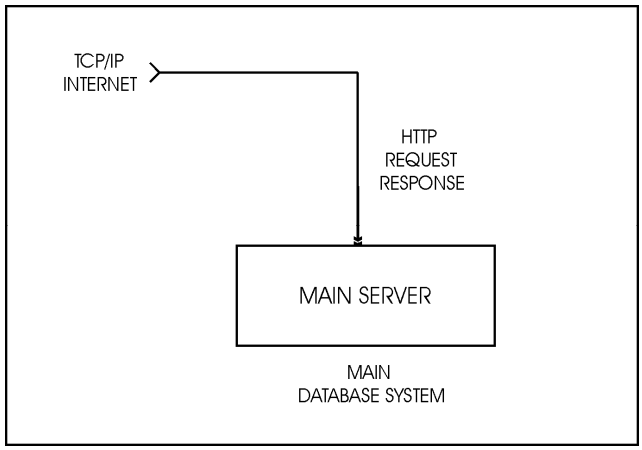

Figure 5. State Center

3 CONCLUSION

Described system presents new approach in improving overall demining process. It gives possibility of real-time tracking of the demining process and automatically acquires all relevant information. It logically connects different demining locations, providing top view from the state center over region centers and field units, down to the each deminer step in the field. Collection and analysis of sensor probe responses can lead to discovery of tool-failure cases or other physical problems with mine detections, analyzing and adjusting mine classification algorithms in cases of wrong classification, automatic learning classification algorithm parameters, automatic storing time and coordinates of every detected mine position and producing mine map locations. All of these improves quality and efficiency of the demining process.

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