SENSATE-LINER EPLRS TELEMETERED DATA INPUT FOR ENCOMPASS

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ABSTRACT

A systems engineering development for acquisition, transmission, processing, dissemination and display of information vital to combat casualty care and related first responder activities is presented. It utilizes a synergistic combination of two existing state-of-the-art Defense Advanced Research Projects Agency/Space and Naval Warfare Systems Center San Diego (DARPA/SSCSD) technologies (Sensate-Liner and ENCOMPASS) coupled via the Enhanced Position Location Reporting System (EPLRS), an existing wireless military tactical communication data system. Transmission Security and Communication Security (TRANSEC/COMMSEC) of environmental and biomedical data is thus accomplished from the battlefield via selected data links and Ethernet. System functionality and appropriate candidate interfacing technologies will be discussed.

KEY WORDS

Sensate Liner, EPLRS, GPS, combat casualty care, remote physiology telematics, smart shirt, wearable computer, ENCOMPASS, first responder.

INTRODUCTION

Recently the Department of Defense (DoD) conducted an initiative to improve the survivability of soldiers wounded in combat. Since the Civil War approximately 80% of seriously wounded combatants exsanguinate before the appropriate intervention can be effected. A recent DARPA/SSCSD program called the Sensate Liner addressed this issue by providing a definitive determination of casualty status and a useful estimate of biological damage. This information can only be applied, however, provided an effective combat casualty medical communications system is in place to alert the required personnel in a timely fashion. This paper describes such a system, which for the sake of
discussion is divided into four sections. First discussed is the applicability of modern soldier and medic mounted wearable computer technology to combat casualty care. Then the novel Sensate Liner type uniform capabilities are discussed as efficient and affordable biological and environmental data collection and intervention platforms. An existing effective telecommunications link (EPLRS) is then described utilizing known hardware for transmission of the data to personnel charged with medical situational awareness and medical trauma intervention. Finally, a DARPA system (ENCOMPASS) is described which provides first responders the clearly developed and processed information they need to provide effective intervention.

MOBILE INFORMATION TECHNOLOGIES FOR COMBAT CASUALTY CARE

Mobile information tools continue to emerge from industry at an accelerating rate. Critical technologies relevant to critical care support include improved computing resources, innovative information displays, interaction tools optimized for portability, a range of small imaging sensors, and wireless communications infrastructures. These technologies can provide the user with responsive, easily accessible task and decision support at virtually any work location. Although such tools may work well independently, however, it is their combined interaction that provides major advances in mission effectiveness.

Computing and storage power for wearable or hand-held computers expands at roughly the same rate as desktop units, owing to the increased interest in these portable devices for an ever-widening range of industrial jobs. Typical commercial systems feature Pentium II Central Processing Units (CPU’s) in the 233 MHz class, with Random Access Memory (RAM) resources of 160 MB and integrated hard drive storage of 8 GB; many vendors have already announced systems with greater power.

High-resolution color displays (e.g., 640 X 480 pixels), readable in both bright and dim light, are now available in hand-held and head-worn variants. While hand-held systems are most common, head-mounted displays (HMD’s) support task performance in unique ways. In particular, HMD information is always available in the field of view (Fig.1) so the user does not need to look away from the workspace.

Miniaturized keyboards, keypads, and mouse tools are already familiar to users of portable computers, although stylus tools and speech recognition are becoming more common due to PDA popularity and the growing need for hands-free computer interaction in offices. In addition, gesture control methods (i.e., computer interaction using hand and finger movements with specially instrumented gloves) are being explored to further reduce the need for conventional input devices in the field.

Fig. 1. HMD
The utility of mobile information devices is enhanced when they are equipped with sensors that either capture data about the environment or extend human senses. Video and still cameras are commonly used in industrial settings to support maintenance collaborations with remote technicians, and both military and civilian communities have employed thermal and low-light sensors during firefighting and surveillance tasks. Such applications typically require knowledge of user location, and the use of commercial Global Positioning System (GPS) units with these information devices is becoming more common.

Finally, whether recording data on site (Fig. 2), transmitting data to another site, or accessing remote data resources, essentially all naval jobs involve information sharing. Portable information tools on the commercial market typically offer some form of sharing through physical transfer (e.g., computer docking), or through radio, infrared, modem, or cell phone connectivity. Most recently, wireless Local Area Network (LAN) technologies – and Internet-based communications methods – have become a primary focus of fleet interest for distributed information exchange aboard ship. Internet-based communications are useful for linking networks of people and data sources with each other.

It is a relatively straightforward matter to extend the capabilities provided by mobile information technologies to the essential needs of combat casualty care: access to medical data, support for casualty assessment, data recording capability, and consultation assistance.

The information storage capacity of current wearable computers and hand-held data assistants can provide a wealth of on-site support data, including diagnosis and treatment procedures, patient history records, and medication characteristics. Such information can enhance the speed and accuracy of field medical response. Attaching special sensors, e.g., physiological monitors, thermal and conventional imaging cameras, etc., to available data ports can provide more accurate field assessments (especially if such results can be analyzed by internal diagnostic software programs) and can simultaneously record test results for later review. Finally, wireless data sharing can provide a complete foundation for field medical personnel to gather and transmit casualty data from the encounter site, to confer with remote experts (Fig. 3), and to record care procedures in advance of patient transport and processing.
Mobile information systems, portable information displays, and wireless communications have all been successfully tested in a variety of military field applications. Combat casualty care places an extra criterion of reliability on system performance, where human life and welfare are at risk. The integration of current mobile information technologies with a Sensate Liner substrate, augmented with EPLRS communications support, can provide just such reliability for this mission.

**A SENSATE LINER COMBAT UNIFORM FOR BIOLOGICAL DATA COLLECTION**

The Sensate Liner (SL) for Combat Casualty Care Program developed a novel combat uniform consisting of a medically instrumented wearable circuit garment useful for monitoring the medical condition of combat soldiers. The SL mesh (Fig. 4) forms a conductive back plane hosting and integrating sensors for biological phenomenon such as blood pressure, pulse rate (heart rate), etc.; physical sensors including - barrier penetration, motion, position etc.; environmental sensors such as temperature, etc. The initial proof of concept suite includes sense modalities for heart rate, respiration, torso penetration (occurrence, classification and localization), and motion. Of particular interest is the detection and location of high-speed projectiles penetrating the human body. Experimental results utilizing polymer acoustic transducer arrays indicate entrance wound locations can be detected and projectiles tracked through the body with an acceptable degree of accuracy. The SL, while individually tailored, will utilize computer automated design technologies such as laser scanning amenable to custom mass production.

The SL is being designed to meet the performance requirements associated with combat usage and typical textile characteristics of durability, wear ability, usability, maintainability and manufacturability, and the integration of the twin objectives realized through interconnected sensors. The information-processing garment should be an “integral” garment, flexible and comfortable to the wearer.

Measurements from acoustic sensors employed individually and grouped as arrays have tracked the projectiles through gel phantoms, allowing presentation of a 3-D virtual reality display to medical personnel depicting biological damage and suggested medical intervention via Mobile Hospital (DEPMED) coding. Vital signs detection (Fig. 5), classification, localization and tracking of battlefield penetrants and vital signs has been demonstrated feasible in combat soldiers. Vital signs of personnel wearing the sensate liner can be continuously monitored such as the electrocardiogram (ECG) tracing.

Probably most significant impact of this development is the area of patient wearable biomedical sensor integration. The circuit garment technology provides the capability of conducting a flow of energy (and thus information) about the surface of the human body,
enabling continuous, comfortable, reliable, and detailed monitoring of biological and environmental phenomenon. This makes cost effective patient monitoring a reality. The extension to other wearable computer applications is straightforward. Secondly, for combat casualty care applications the torso penetration sensor suite allows improved estimates of biological damage to a medic display as well as physiological monitoring to improve triage and battle field medical intervention. Further development will provide a high confidence level in user acceptance of the SL to the standard suite of military battlefield gear.

A variety of medical applications such as in and out patient monitoring, prenatal monitoring, infant monitoring, geriatric and intensive care, may benefit from the use of this technology. It is hoped this technology will find wide use in the medical field.

The SL is a major step towards the development of an “Artificial Nervous System” for space and terrestrial biomedical monitoring and intervention, as well as human performance enhancement. However to be effective this information must be transmitted to and managed by responsible parties for effective monitoring and intervention. The combination of fielded computational assets combined with the greatly enhanced capability for biological sensor data acquisition represented by the SL is expected to result a greatly increased opportunity for effective intervention as well as an increased military requirement for medical data transmission. In pursuit of this opportunity the remainder of this paper discusses an approach to medical data transmission and analysis for remote physiology telematics data management.

**EPLRS DESCRIPTION**

EPLRS provides two main functions for the military: a secure, reliable digital communications system, and the position of each radio (PLI). A secondary function is navigational aids (NavAids), such as lanes, zones, and air corridors. EPLRS transmits data packets in a Time Division Multiple Access (TDMA) architecture to provide a robust, self-healing communications network, which is why it is the tactical data distribution workhorse for the Army and Marines.

EPLRS is a network of Radio Sets (RS’ s) centrally controlled and coordinated by a Network Control Station (NCS). The NCS hardware configuration consists of a high performance, open architecture computer (TAC-4), a timing master RS called the Downsized Enhanced Command Response Unit (DECRU), crypto devices, and a printer. NCS’s are installed aboard ships, or mounted in vehicles. The RS is extremely rugged, meeting full military specifications. Each RS has two external data ports. One port is for
the User Readout (URO), a small, 2 text line military standard handheld device. The other port is used for the host computer connection. Recent downsizing of the EPLRS NCS components also supports a carrying case version for optimum mobility and reduced cost.

EPLRS is network centric at the NCS. The roles of each RS in the network are pre-planned and entered into libraries which define the network participants and how they interact. All RS’s are automatic participants in the control network, which establishes and maintains connectivity between the RS’s and the NCS, which is the basis for each RS’s position calculation. EPLRS uses Time of Arrival (TOA) messages from each RS to perform multilateration tracking calculations. The reference community is anchored by at least three surveyed reference RS’s at fixed locations. Tracking accuracy is improved greatly as the number of high quality references increase.

After initialization by the NCS, the communications network will continue to operate if the NCS goes down. However, the PLI which is calculated by the NCS, would not be available.

Fixed reference sites are a major deterrent to mobile operations especially in “from the sea” operations where there is no basis for fixed reference sites. To offset this deficiency, the government developed a GPS interface unit (GPSIU) which connects to the URO port on the RS and passes GPS generated positions to the NCS via the RS. A minimum of three GPS equipped RS’s are required as reference units in flat terrain with good RS geometry.

Although the loss of GPS through jamming may degrade mobility of an EPLRS equipped war fighting community, it does not degrade the tracking accuracy of an established, fixed reference network. EPLRS tracking accuracy is as accurate as GPS, if good community geometry is maintained.
Fig. 6 is an example of the Navy’s use of EPLRS in an amphibious assault. The primary components of the Amphibious Task Force (ATF) are: the Amphibious Command Ship (ACS), the Primary Control Ship (PCS), the Secondary Control Ship (SCS), Landing Craft Air Cushion (LCAC), the Airborne Relay Platform (ARP), and the Marine Expeditionary Unit (MEU). Communication support ranges from 100 miles at sea to 200 miles inland.

Such a deployed EPLRS network provides a unique jam resistant asset available for communication of the quantities of medical information provided by the “smart uniforms” of the future such as the SL. The final requirement to complete the combat casualty care system is a platform to provide for data analysis, display, and response coordination. This platform we find in ENCOMPASS.

ENCOMPASS SYNOPSIS

ENCOMPASS is a computer-based program that assists in disaster and patient information management. It consists of several components that can function as a unit or independently based on the needs of the individual user. It provides incident commanders and first responders with a common operational picture of the incident scene. Forward responders actively collect data that is automatically fed into a database. Thus a situational awareness is provided to all by displaying location, identification of resources and personnel, a geo-referenced map of the incident location(s), availability of hospitals in the vicinity, etc. This information is kept current through fast updates and is displayed simultaneously to all ENCOMPASS systems.

ENCOMPASS provides planning, resource and casualty tracking, simultaneous documentation of multiple events and incident accountability. The planning includes standard operating procedures for handling various type incidents as ready-for-use
checklist of requirements. The tracking of casualties includes the location of all casualties, responders, equipment and supplies that are necessary to control the event(s).

ENCOMPASS consists of 2 subsystems – Incident Command Management System and DARPA-Syndromic Surveillance System. The former consists of the following components: Electronic Watchboard, Crisis Application Planning System (CAPS), ViewPort, e-WebApps, TACMEDCS (Tactical Medical Communications System), and Fire Department (FD) on Scene. The latter consists of Patient Encounter Module, BASIS (biomedical surveillance component), and MedView. ENCOMPASS can be utilized as a whole with all components or with as little as one or two components depending on the need/requirements of a specific user.

The EPLRS use is suggested because under jamming conditions very few existing communications systems will be operational and EPLRS is one of them, which is relatively less costly. This is not to say that EPLRS is jam proof. But as communication systems go EPLRS is one of the more resilient ones.

In summary, the ENCOMPASS system provides: enhanced communication between hospitals and operation centers, fast-time casualty tracking, fast-time hospital reroute status (all using Web-based components); and an Application Service Provider (ASP) model which provides sharing of treatment protocols as well as an after action reporting capability.

CONCLUSION

This paper presents a system capable of providing the necessary data required for effective intervention from combatants equipped with Sensate Liner capable uniforms to designated first responders. The elements required are substantially demonstrated, and while further development and interfacing is required the feasibility of deploying such a system successfully is very high. This system essentially collects the appropriate diagnostic information, communicates and processes that information in order to provide the required alert and suggested interventions recommendations and commands for saving casualties.

REFERENCES


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