Presentation Title: A Standardized and Modular Object Model for Medical Modeling and Simulation for Distributed Training

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Abstract:

Purpose:
This paper describes work done to-date in developing a standardized, modular, data object model to support simulation-based training of medical personnel.

Benefits:
A standardized data model is highly useful as a foundation on which diverse real and simulated systems can interact. A standardized data model can reduce costs and risks in developing and maintaining related programs. In addition, a standardized data model can be a valuable part of specifications to procure training systems that are interoperable by design.

Key Take-aways:
The reader will understand progress made to-date towards development of a standardized data object model being built under contract to a US Government agency, enabling standalone and distributed training. This model has been implemented in a Federation Object Model (FOM) for use in training systems based on the IEEE-standard High Level Architecture (HLA). The result is a Medical Modeling and Simulation Federation Object Model (MMS FOM) which will be delivered to the US Defense Health Agency in the summer of 2019.

Background:
To date, simulation as a technology applied to medical training has largely meant standalone systems, such as mannequins to simulate human bodies (patients), virtual reality to simulate surgery, and scenario-driven training activities. However, simulation-based medical training based on distributed training involving many different systems is emerging. The history of distributed simulation-based training in other domains, e.g. training pilots in flight simulators, clearly shows that the use of international standards and a standardized data object model is a good way to go forward.

The project is part of a contract issued by the Medical Technology Enterprise Consortium (MTEC) and sponsored by the Medical Simulation and Information Sciences Research Program (JPC-1). Development of the MMS FOM is a requirement of that contract. IVIR Inc. (USA) is the prime contractor for the FOM portion of the contract. Subcontractors are: Pitch Technologies (Sweden and USA), Education Management Solutions (USA), SCM Globe (USA), VCom3D (USA) and HC Simulation (USA). The contract, issued in 2017, has the objective to provide a training environment that simulates patient care, evacuation, and hand-offs to replicate the continuum of care to improve patient outcomes. The continuum of care spans care for combat-injured soldiers at the Point of Injury through higher tiered medical facilities.

Since the MMS FOM is a modern electronic data transfer mechanism, it must encapsulate data, procedures and practices currently in use by military medical, transport, and logistics personnel. The trail of documents currently used by combat medics, field and regional hospitals, and major medical facilities, including MEDEVAC transport personnel, must be supported in a training system involving handoffs of patients through those tiers of medical care. For example, at the Point of Injury, a US Army combat medic uses a Tactical Combat Casualty Care (TCCC) card to document patient injuries. Information on the TCCC card is communicated to the next tier medical caregiver, usually in advance but always as part of the patient handoff. As a result, the MMS FOM includes information first documented on a TCCC card.

Approach:
Many years of experience in other simulation domains show that a Publish-Subscribe system architecture along with a standardized data object model would satisfy current and projected future needs for simulation-based medical training, whether standalone or distributed. The prime contractor for the referenced contract chose High Level Architecture (HLA), an IEEE-controlled international simulation standard, as the data interchange architecture because HLA fits this medical training application very well. Benefits of HLA for Medical Simulation-based Training include:

- Proven through 20+ years of development and use
- IEEE standard … non-proprietary, readily available and internationally used
- Suitable for small, large, and very large scale applications
- Publish/Subscribe architecture
- Modular and Expandable
- Efficient data management
- Short time to develop/adapt new applications
- Commercial off-the-shelf tools readily available from multiple suppliers
- Future proof, to avoid “stove-piped” implementations
- Time management features for operation in real-time plus slower or faster than real-time
- Synchronization of subsystems (HLA federates) throughout the larger system (HLA federation)
- Assured data delivery
- Causality and Deterministic, needed for operational integrity & repeatability

Building a standardized Medical Modeling & Simulation Federation Object Model (MMS FOM) requires inclusion of many different categories of information. The MMS

FOM defines the overall data infrastructure through which various medical-related simulators interchange data. Any standalone or distributed medical training system may include these types of information in full or in part. The MMS FOM in its current and still evolving form consists of seven modules:

- Medical Facility
- Physiological
- Transfer of Patient
- Control of Simulation
- Medical Logistics
- Communications
- Instructional

Additional details are included here about two of those modules.

The “Facilities” module has data elements that describe the characteristics of a medical facility, including:

- The immediate area surrounding a combat medic treating a field casualty at the point of injury, which is not generally thought of as a classical medical facility but is, in fact, the first medical treatment environment encountered by a combat casualty.
- CASEVAC/MEDEVAC transportation vehicles
- Fixed facilities, such as field (tents) and regional hospitals
- Mobile hospitals, e.g. US Navy “Mercy” ship

The “Physiological” module contains data definitions about:

- Patients
- Identification, vital signs, oxygen level in blood, and other physiological data
- Injuries
- Injury types (standard medical codes)
- Treatments
- Medicines given, topical treatments, tourniquets, etc.

Results:

A demo Point of Injury related training system of systems is being constructed to verify the approach and first implementation of the MMS FOM. Key components are:

- Interactive 3D visualization (“serious game”)
- Highly advanced physiology engine
- Simulated CASEVAC/MEDEVAC operations
- Capture of patient and treatment data
- Capture of voice communications and related written documentation, in the forms mandated by US DOD policies
- Automated interaction with a Logistics system to track medical supplies
- Integration with a formal Learning Management System (LMS)

Lessons Learned:

In the course of our work, we recognized five major lessons learned: (1) Most medical training devices today were not designed to be interoperable. However, commercial off-the-shelf HLA tools provide a straightforward path to add HLA compatibility to devices and training systems. The MMS FOM will provide a standardized data interchange model for interoperability in future medical training systems. (2) The standardized MMS FOM provides a well-documented data interchange model. It takes time “up front” to determine the data Input and Output capabilities and requirements of each component system, but having a standardized MMS FOM will enable previously isolated systems to interoperate with minimal stress on systems or personnel. (3) Implementing interoperability using a modern, robust simulation framework (HLA) with a standardized data model and modern software tools is relatively easy to do and produces excellent results. (4) Building a modern interoperable system on the basis of old standard paper documents that have been in field use for years, sometimes decades, is definitely challenging. HLA’s modularity and flexible data types have enabled adaptation of paper forms to electronic data. (5) It was critically important to have Subject Matter Experts (SMEs) available to consult (e.g. medical SMEs, logistics SMEs, etc).

Conclusions:

HLA proved itself as a viable architecture for simulation-based training of medical personnel. to enable interoperability of previously standalone products for. A standardized object model took time to coordinate but the result was worth the effort. Future training systems can benefit from our recent work, building on the current baseline and adding modules when needed.

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Biographies:

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ERIN HONOLD: Biomedical Engineer with IVIR Inc. with experience developing medical simulation technologies and architectures for the US Department of Defense. Previous work includes utilizing HLA to design standard architectures for joint medical training focusing on en route care and patient handoffs.