Collaborative: Executable Distributed Medical Best Practice Guidance (EMBG) System for End-to-End Emergency Care from Rural to Regional Center Hospitals

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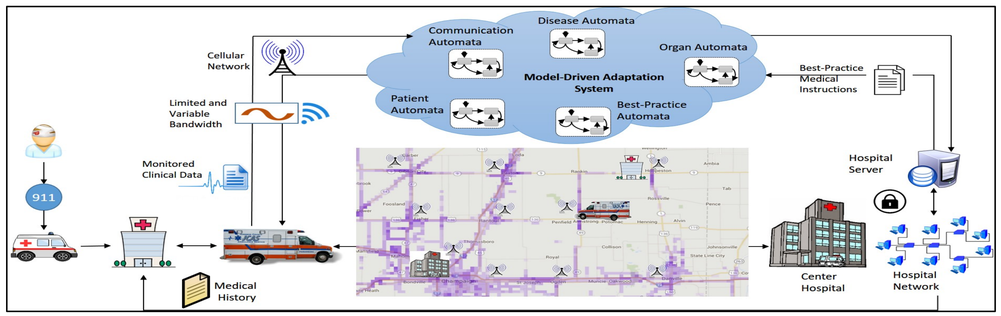
Challenges:

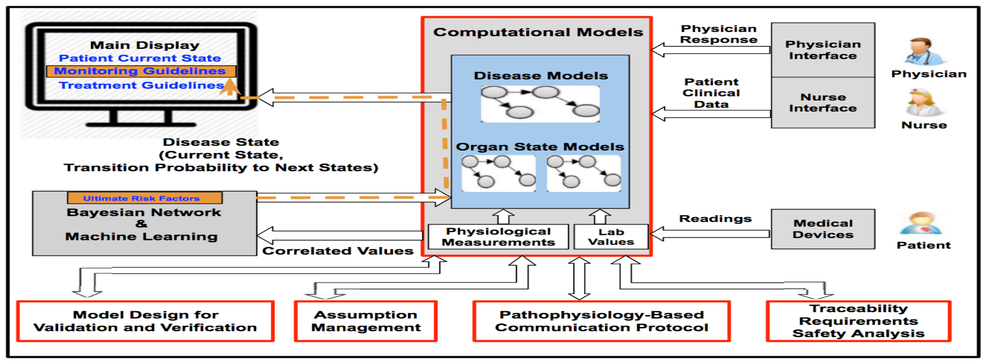
Preventable Medical Errors are the 3rd leading cause of deaths in America. GPS based navigation transform maps and chosen routes into real-time guidance. Can we similarly transform the practice of medicine?

- How can we make medical knowledge executable in the form of a guidance system, verifiable by formal method and validated in hospitals?
- How can we know:
  - if the changes in clinical environment may invalidate the assumptions embedded in the medical workflow?
  - patient's condition change s, is the medical workflow still applicable when facing with unexpected delays?
- Medical guidelines evolve and guidance system for critical care need FDA approval. Tracking the requirement changes effect on safety analysis and corresponding software changes is challenging.

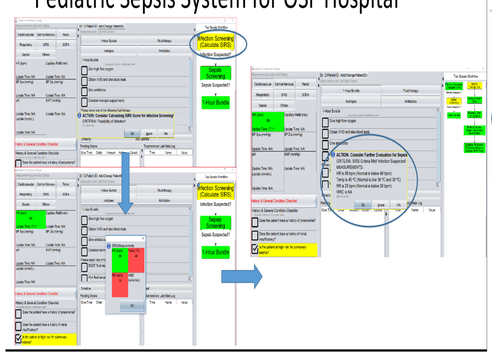
Solutions:

- **Computational pathophysiology**: In the guidance system, medical knowledge is represented as networked medical best practice work flow automata and organ pathophysiology automata; Model development (UIUC), Model verification (IIT); Guidance system validation (Carle, OSHU, OSF)
- **Resource availability and environmental assumption management** : Environmental model and resource availability model are developed modularly but jointly verified with the best practice work flow (IIT)
- **End-to-end traceability** from clinical and system requirements, safety analysis, to design and implementation (UIUC)
- **Device fault model**: Study of software-related causes in the FDA medical device recalls (IIT)
- **Distributed guidance system** across regional hospital, satellite hospital and patient transfer (UIUC)

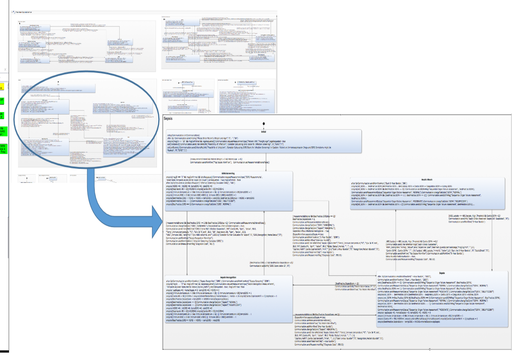




Pediatric Sepsis System for OSF Hospital



Organ-Centric Yakindu Model (Magnified Sepsis Machine)



Scientific Impact:

- **Computational pathophysiology:**
  - Executable model of medical knowledge in the form of networked organ disease automata and best practice automata using statechart model tools
- **Integrated model verification and clinical validation**:
  - The statechart model's stimulation capability allows close interaction with physicians to check the validity of the model
  - The computer-aided translation of statechart Model to UPPAAL verifies the software design integrity.
  - Clinical system assumption management system to help prevent assumption faults.

Broader Impact:

- **Cardiac arrest resuscitation guidance system**: Cardiac Arrest is deadly and there is no room for errors. Our system has been approved for Phase 1 clinical evaluation at Carle Foundation Hospital's ICU
- **Sepsis best practice systems:**
  - **Carle hospital network:** Sepsis has a high mortality rate caused by complex multi-organ failures. Our guidance system has been approved by Carle to start preparing on the clinical evaluation at Carle's satellite hospitals.
  - **NEW: OSF Children Hospital:** Our current sepsis guidance has been designed for adults. OSF Children Hospital has decided to work with us to extend it for pediatric sepsis
- **Heart transplant:** We have been working with OSHU on the requirements and high level designs for a heart transplant perioperative guidance system.
- **Education**: We start developing best practice guidance system based sepsis training course for the new Carle-UIUC Medical School's medical students.

Illinois Institute of Technology http://gauss.cs.iit.edu/~code/

University of Illinois at Urbana Champaign https://publish.illinois.edu/mdpnp-architecture/

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