ITR - (ASE + NHS) - (int): Intelligent Human-Machine Interface & Control for Highly Automated Chemical Screening Processes

Revised Project Work Plan

As a result of budget revisions requested by the NSF, the following changes were made to the scope and duration of the ITR project:

(1) We eliminated the remote robot fault monitoring system development (described in Sections 3.3.1 and 3.4.2 of the original proposal).
(2) We eliminated the cognitive model sensitivity analysis (described in Section 3.4.3).
(3) We shifted the process modeling and control system development work (described in Section 3.2.1) from Year 2 to Year 1 in order to accelerate the research cycle and to achieve the remaining project objectives within a 3-year period.
(4) The project duration was reduced from 4 years to 3 years.

Consequently, the remaining major tasks for the project include:

- conducting the cognitive task analysis with current chemical screening process operators at CELISCA;
- developing the process model to describe remote, closed-loop control of the screening process;
- developing the cognitive model of supervisory control of the chemical and toxicity screening processes in order to make predictions of operator task performance under various operating circumstances;
- prototyping a supervisory controller interface considering operator information requirements and usability;
- linking cognitive model predictions of operator performance to adaptive interface content to optimize operator perceptual knowledge and process SA;
- identifying operator physiological variables for classifying operator functional states;
- developing neural networks to automate operator state classifications; and
- integrating the supervisory controller cognitive model with the operator physiological data model as a basis for making accurate predictions of operator performance in screening processes under low and high workload conditions.

Below is a table presenting some of the specific steps to each of these tasks and a general timeline.

Year	Semester	Task
2004	Fall	*Conduct goal-directed (cognitive) task analysis* of chemical and toxicity screening processes using videos of simple chemical experiment procedures presented to expert process supervisory controllers, lab technicians, and chemists. Identify operator information requirements for phases and specific tasks of chemical screening.
2005	Spring	*Develop cognitive model of supervisory controller behavior* based on results of CTA – develop extensions to ACT-R cognitive architecture for modeling touch input devices (with portability), including tablet PC.

2005	Summer	*Conduct cognitive model validation* experiments with CELISCA operators. *Develop detailed concept of remote, closed-loop control* of the CELISCA chemical screening process, specifically master (line) robots. *Develop mathematical model of process control scenario* involving single user direction of multiple, remote robot actuators at CELISCA.
2005	Fall	*Simulate CELISCA Robot Unit and Communications Unit in process model* (using time-domain based representations) to *investigate effectiveness of cognitive model in accounting for communication delay conditions in predicting human operator robot control actions*.
2006	Spring	*Prototype interactive information displays* to address information requirements of supervisory controllers. *Design interface content and formatting for control interfaces and shared SA display* for basic toxicity test tasks. Use CELISCA operators for informal usability tests. *Assemble collection of prototypes in graph for use in adaptive interface development*.
2006	Summer	*Develop UIMS* in which cognitive models drive dynamic reconfiguration of interface for screening process operators. *Create prototype of intelligent interface* on tablet PC.
2006	Fall	*Conduct formative evaluation of adaptive UIMS*. *Conduct usability evaluation of UIMS with CELISCA operators* and formal summative evaluation.
2007	Spring	*Develop measures and indices of screening operator workload* using non-invasive physiological parameters. *Conduct experiments in Rostock medical lab and in real screening process facilities to describe characteristics of operator physiological states* under various process workload conditions.
2007	Summer	*Develop NN for operator functional state classification in screening process control based on physiological variables* and operator task performance. *Conduct experiment at CELISCA to collect data on operators under various workload conditions for training/validating network. Develop final cognitive model considering physiological states of operator* during various phases of chemical screening process.

The major activities that were identified for CELISCA in the "Research Coordination Plan," as part of the ITR proposal included:

- investigation of human physiological load/strain in use of highly automated life science processes;
- development of effective data analysis interfaces for web-based access of screening processes data and data on operator physiological responses; and
- technical optimization of human-machine interaction for high-throughput screening systems.

This list may change based on the budget changes to the ITR grant and the reductions in the proposed NCSU effort.