## Collaborative Human-Machine Interfaces (**KY - Interface**)

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This NSF-EPSCOR Center will bring together intellectual leaders from our state who together will contribute to advance the state of the art in the multidisciplinary research field of **collaborative human-machine interfaces (CHMI)**. The proposed center will fulfill a much needed synergy between diverse researchers, while also building the necessary infrastructure capacity to advance the state of the art, and educating a much needed STEM workforce. Future CHMIs enabled by research at KY Interface Center will lead to a tight convergence between humans and machines that is *consistent with NSF's Work at the Human-Technology Frontier, and also matches Kentucky's Strategic Plans of High Value R&D in Areas 3, 4 and 5.* Proposed CHMIs will not only correctly interpret human intentions, and help translate them into appropriate control signals for safe collaborative machines, but will also adaptively improve usability based on learning user preferences and performance while continuously measuring interaction performance.

It is envisioned that within the next two decades, CHMIs for home, healthcare and manufacturing environments will become as ubiquitous as mobile phones of today, and therefore by supporting this project, the state of Kentucky could be propelled to the forefront of an upcoming global transformation with a relatively modest investment. Although there is a growing demand for collaborative HMIs, there are still many remaining research challenges related to safety, intuitiveness, and efficiency of interaction between humans and machines. The overall goal of the KY-Interface Center will be to conduct research and evaluate effectiveness of future CHMI technologies such as novel software algorithms based on learning and adaptation, new human activity sensor hardware. Leading applications for our research will be advanced manufacturing such as: *industrial automation for manufacturing, assistive device manufacturing, and service robotics for home, agriculture and warehouse logistics*.



*Figure 1: An adaptive human-machine interface will accept input from a variety of sensors and devices, and continuously evaluate results in a feedback loop. Inputs may include "old technology" such as PDAs, gaming controllers, speech commands, and "future technology" such as pressure sensitive skins, wearable sensor fabrics, brain-computer interfaces. Adaptation at the interface will be accomplished by neuro-adaptive feedback control and machine learning for co-manipulation and skill transfer.*

Pictures from Figure 1 are from Popa's NSF-funded work with Personal Robot-2, Zeno (for Autism treatment), Phillip K. Dick (a social humanoid), as well as prosthetics and industrial robot hardware through grants MRI #0923494, CPS #1035913, NRI #1208623, PFI #1643989, I-Corps #1713741.

We propose that the multi-disciplinary KY-Interface Center be a partnership led by the Speed School of Engineering at University of Louisville (U of L) and the College of Engineering at University of Kentucky (UK), involving a dozen core faculty from the departments of Electrical and Computer Engineering, Bioengineering, and Computer Science at the two institutions. In addition to the core faculty, we envision that KY-interface will solicit and fund seed projects for affiliated faculty of the Center. These faculty will be either newly recruited faculty whose startup research packages are supported through KY-Interface, existing junior faculty at UofL and UK, and other Kentucky research and education leaders.

Collectively, these faculty cover diverse expertise relevant to CHMIs and their applications, including machine learning, intelligent control, rehabilitation, robotics, bioinstrumentation, data mining, and microfabrication. In addition, the Center will provide a formal mechanism and funding to increase the initial number of participants through seed projects involving newly recruited faculty, affiliated faculty from U of L, UK and other research institutions in KY, and collaborations with other departments, such as the Schools of Medicine, Nursing, Science, Business and Special Education. Our center will help attract, develop, and retain technical talent in our state: we anticipate recruiting at least 4 new faculty of international stature to the state of KY over the next 10 years, funding at least 10 collaborative projects and dozens of graduate and undergraduate students at the participating institutions. We will also reach out to local K-12 institutions and to other state community, and technical colleges for evaluation, outreach and dissemination.

The project core faculty already have more than 10 active research grants and an extensive track record at the National Science Foundation, which will leverage the additional investment and give exceptional credibility to a future NSF-EPSCOR proposal. Research activities will be nicely integrated into hardware and software testbeds and demonstrations that will provide tangible metrics for our research and will guide the overall project schedule.

| Table 1: KY-Interface Core Faculty Expertise | Manufacturing/Logistics Testbeds |
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| **Dan Popa (U of L Lead)** <br> Robotics, control, micromanufacturing <br> **Olfa Nasraoui** <br> Data mining, machine learning, and recommender systems <br> **Gina Bertocci** <br> Rehabilitation science and engineering, bioinstrumentation <br> **Shamus McNamarra** <br> Microelectronics and MEMS <br> **Karla C. Welch** <br> Robotic autism therapy and wearable biological sensors <br> **Kevin Gue** <br> Design and control of distribution, warehousing and material handling systems. <br> **Yu Ming Zhang (UK Lead)** <br> Neuroadaptive control of manufacturing process <br> **Sridhar Sunderam** <br> Brain-machine interfaces for rehabilitation <br> **Sen-ching Samson Cheung** <br> AR/VR, medical intervention, privacy, and security <br> **Michael Johnson** <br> Speech recognition and machine learning <br> **Ruigang Yang** <br> VR, machine learning, computer vision <br> **Brent Harrison** <br> Artificial Intelligence, Machine Learning, Game Design | 1) Human performance augmentation for co-robotic part manipulation/assembly and attachment (M1) <br> 2) Micro/nano manufacturing of MEMS devices (M2) <br> 3) Part fetching in automated warehouse (M3) <br> 4) Intelligently coordinated robotic team for complex industrial processes (M4) <br> 5) Enhanced welder training through human-machine collaborative systems (M5) <br> 6) Mobile manipulator for factory and hospital environments (M6) <br> 7) Personal ambulation and mobility in factory environments and distribution centers (M7) <br> 8) Virtual and Augmented Reality platforms for factory skill training (M8) <br> 9) Other interfaces for manufacturing |