The Kentucky Smart Systems Center – Phase 1: Advanced Manufacturing in K-12 Education and Health

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Overview: Advanced Manufacturing is the “use of innovative technologies to create existing products and the creation of new products. Advanced manufacturing can include production activities that depend on information, automation, computation, software, sensing, and networking”1,2. From state figures3, the manufacturing sector employs 14% of the population and healthcare sector employs 14.5%; both are above the national average. Professional, scientific and technical services employs 4%; while national average is around 6.7%. The information sector employs 1.6% while national average is 2.1%. K-12 education is a national problem. On the K-12 Achievement Index, made up of 18 distinct indicators capturing current academic performance, gains over time, and equity as measured by poverty-based disparities; KY ranks around 30th in the nation with a C grade4. Anxiety and depression with children is also alarming in the US. These behavioral issues have many adverse effects. For example, statistics show that the most vulnerable group for suicide is teenagers. Each day in our nation, there are on average of 5,240 suicide attempts by young people grades 7-12. And four out of five teens who attempt suicide give warning signs. Estimates of annual health spending for a comprehensive set of medical conditions are presented for the entire US population and with totals benchmarked to the National Health Expenditure Accounts. In 2013 mental disorders topped the list of most costly conditions, with spending at $201 billion. KY is above the national average in suicide rate. It is not known how KY pars with the national average for care of autistic, deaf, blind, quadriplegics, and the elders. Yet, Louisville is the home of the American Printing House for the Blind (APH), the oldest company in the United States manufacturing products for blind and visually impaired people, and the world’s largest such company. Therefore, an agenda for advanced manufacturing in education has many facets.

The PIs of this project propose to incubate an advanced manufacturing agenda for smart systems in the education and related healthcare. The PIs have a collective 10+ decades experience and expertise in signals and systems, biomechanics, biometrics, sensors and communication, and vast experience with smart system design; e.g., humanoid and autonomous robotics, activity monitoring, tele-learning, speech analysis, and wireless communications, in addition to a wide nest of collaborators in education, psychology and biomedicine, which motivates the proposed agenda. Advanced manufacturing will bring about three main components: a) reinventing various bulky and wired systems which gather data from the human muscle activation of various organs; b) incorporating advances in communications and information technology into development of prototypes in K-12 education; and c) establishing a robust virtual network of collaborators in KY to cultivate an ecosystem for advanced manufacturing in education, healthcare and other domains, through the creation of the Kentucky Smart Systems Center (KSSC) which we submitted as an idea paper to the KY NSF EPSCoR.

Specifically, we will design and fabricate the sensor networking for data collection from the face and muscle, using advanced simulation and prototyping; we will invoke the wireless technology at the macro scale for non-intrusive applications of measuring attention and surveillance of signs of depression; we will link KY educational centers (e.g., The UofL Delphi Center) with the state’s middle and high schools for invoking “adaptive learning” into the curriculum at earlier stages. Most importantly, we will establish a student-centered system for quantifying several indicators of engagement, attention and early signs of withdrawals. The proposed agenda is within KY S&T plan and the NSF top 10 ideas; it is also within the KY NSF-EPScOR theme on advanced manufacturing ecosystem, especially in autonomous systems, embedded sensors and the applications in health. Indeed, this endeavor will generate unprecedented big data that will entice huge R&D in education and childhood health, which will establish and promote various startups in KY. Needed resources include: creation of two research faculty lines with specialties in education technologies, sensors design and fabrication; material components for building sensors at KY-based facilities; components for wireless communication hub for smart systems; support for students and partial summer support for the PIs. The research faculty lines will add needed talents and would galvanize the R&D agenda.

Intellectual Merits: The first phase of KSSC will focus on developing technologies for K-12 education; Fig. 1. This will be achieved through R&D of novel technologies to quantify and enhance education, measure early signs of anxiety and depression, and will integrate special-needs children to reap the benefits of their healthy counterparts in the US. This proposal has three specific aims, Aim 1: to research and develop prototypes for non-invasive technologies that will assist in K-12 education, which will include measuring attention, degree of engagement and incorporation of technology in the classroom. Such technologies include creation of sensors on thin sheets and wireless connectivity for data acquisition of biological data. Aim 2: research and develop prototypes for non-invasive technologies that will capture and integrate critical signals that humans project (e.g., vital signs, gait, hand function, facial expression, and speech patterns) to assess engagement, emotional state, and disposition for learning without intrusion, threat or adverse effect on privacy. Aim 3: Build a close collaboration among the state’s universities and startups, to translate the prototypes and models created as a result of Aims 1 and 2 into commercialization, using advanced manufacturing processes that are efficient and environment friendly.

Broad Impact: This proposal is a step in a big domain of smart systems in education and healthcare. Discoveries will be applicable to autonomous systems, elderly care and sports; it will promote new startups and consolidate linkage with existing ones. This project includes basic and applied research within the agenda of the NSF and addresses a critical problem for KY and the nation as a whole. The proposed technology will have immediate applications to elderly care, rehabilitation and transportation and other industries.

3 http://www.netstate.com/economy/ky_economy.htm
Figure 1: Overview of the agenda to be pursued in Phase 1 of a Kentucky Smart Systems Center (KSSC), which will focus on developing novel technologies to improve children education and understand ominous signs of depression and withdrawal from healthy behavior.

Figure 2: Summary of the main research thrusts to be pursued in invoking advanced manufacturing in K-12 education.

- **Total Budget**: Approximately $1.5M a year for five years span. Main line items are hiring research faculty lines, acquisition (including fabrication) of sensors for non-intrusive data collections, and graduate students support.

- **Long Term Sustainability**: Proposals to various agencies; IP licenses to various manufacturers and creation of startups.