Personalized Manufacturing: Psychology and Sociology as Fundamental Design Elements in Future Advanced Production Systems

What if there was a factory designed around people, with an innate understanding of human behaviors, emotions and motivation, and able to detect and adapt in such a way that instinctual reinforcements are stimulated, and people are inherently driven to be engaged? There would be competition for open positions, and those that work there would be in awe that they are getting paid to do something so enjoyable. Despite current research efforts in human-machine interfacing, the emerging digital enterprise embodied by the Internet-of-Things virtually ignores true human integration, arguably the most essential element of manufacturing (even to the point of calling them "fools" as in foolproofing). We conjecture that this emotional disconnection fosters apathy and derision and drives the manufacturing system away from best performance. Herein we propose embracing human emotions and abilities in the context of *personalized manufacturing*.

Today's manufacturing systems are characterized by predictable, deterministic and stationary behaviors with a goal of continually decreasing variation; we have lost the opportunity to leverage the creativity and adaptability of the human machine. What if manufacturing system design was based on the large body of social science research in how humans react and behave? Integrating knowledge of human abilities, attitudes, motivations, preferences, and limitations into manufacturing systems would create a disruptive way of thinking about how parts are made by people. Themes include: evolving technologies for extracting human information and applying it to control, state identification of human behaviors, bounding AI capability and fusing it with human ability, combining stochastic belief evolution with psychological theories to account for stress, and defining the psychology of the machine.

Some inspired fields of research areas are: Leveraging psychosocial models of the worker (having a holistic understanding of behaviors applied to manufacturing systems, and how the psychology of individuals and the sociology of teams can be augmented through embedded hardware and software); Defining the emotion of manufacturing (keeping workers excited and motivated over the long term; inverting this to invent emotional control of robots and machines); Creating the video game of manufacturing (understanding the ferocity of attaining the high score, and how intermittent reward systems such as gambling influence behavior and emotion); Negative predictive reinforcement (predicting future bad behaviors through state estimation, and deterring before they happen) and; Plasticity (investigating how manufacturing systems designers could use training to manipulate or delete memories in order to foster optimal behavior in light of new technologies; define the manufacturing *tabula rasa*). If the system understood in real time how a human would respond, it could adapt presentation of work and parts, and modes of communicating information (*e.g.*, distractometer input drives hologram-based work instructions). Such individualistic approaches will stimulate basic human instincts, and work to affirm the human's feeling of purpose and contribution, thereby reinforcing behaviors that enhance performance.

Such an integrated effort will require in addition to engineers: psychologists, sociologists, biologists, pedagogy researchers, computer scientists, logicians, systems thinkers, and experts in privacy, security and philosophy. How could one use the tools of digital manufacturing such as Big Data Analysis and Deep Learning on human data streams, in order to understand the patterns of people's performance and feeling, and the effect on manufacturing and overall quality of life? We could realize value beyond profit and brand image, to holistic benefits for workers. Emotional beings don't fit in a deterministic environment; we need an Internet-of-People-and-Things.