Building a Human-Intelligent Metaverse

Michael Zyda, University of Southern California

This article describes research into computational human perception's potential to be the core of a human-intelligent metaverse, a sensed world that interacts with our physical, emotional, and mental states.

In Zyda 2022,[1] I pointed out that almost every networked game was being renamed and repurposed as a portal to the metaverse. As far as I could see, there was not much difference in these various metaverses; they just seemed to be networked games where players could create their own 3D avatars, with some advertising for the fact that players could "create their own game inside of the so-named Metaverse." Now, we have been creating our own game avatars for just about forever, so that is not really new. Perhaps it is better-looking 3D this time, but the idea is not new. We used to call building a new game inside of another game a "game mod," and such mods have been around for a long time, with probably the most popular one I can think of off the top of my head being *Counter-Strike*, which came out in 1999. I built an entire game development team out of hires from the *Counter-Strike* mods community, and we got to build the *America's Army* game together.[3,4] So, what is new about the various metaverse portals? They seem like something we have seen for years. Well, they certainly look nicer graphically then what we were building in the 2000 time frame, but are they all that different? Or is the metaverse just a marketing term, one to satisfy the desires of venture capitalists so that they can say they are investing in something new, not just something where all the key features were straight out of 1999?

On top of this rebranding effort, we also have the cryptosquad and the nonfungible token (NFT) mavens all trying to hang their scammy little selves on the metaverse so that perhaps they can grab hold of some of that venture capital lucre. And most of the smart money people I know are running away from crypto and NFTs as fast as

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EDITOR **MICHAEL ZYDA**
University of Southern California;
zyda@usc.edu

possible. The only people I know still going after crypto and NFTs are those who are hoping beyond hope that they will catch something akin to the Bitcoin run-up that they all missed earlier in the past decade. I know two people who made money on the Bitcoin run-up, one a former child star who took all his winnings to Puerto Rico to avoid capital gains taxes and one who was the teaching assistant for my mobile games class, and he got his Bitcoin by winning a contest. He lost track of the Bitcoin for a while until he realized that he could pay off his University of Southern California tuition with those winnings. The rest of the people I know who invested in Bitcoin did so long after the run-up and are now watching the currency rapidly lose value and praying that NFTs will save their sorry souls ...

So, desiring to throw my hat into the ring for what we really ought to do with the metaverse, idea number 32,768, is to create a human-intelligent metaverse (HIM), a metaverse that is designed around the idea of sensor-based games.[2] The idea is this: we want to utilize biosignals captured from sensors, the interpretation of those biosignals (physical, emotional, and mental states), and behavior models for building a sensed world capable of modeling and interacting with humans. We will call this the *HIM*, as opposed to the game-mod metaverse (GMM) that is currently being built.

WHAT WILL WE BE ABLE TO DO WITH A HIM?

Let's start by describing what we can do with the GMM. With the GMM, we can put on a head-mounted display, perhaps put on some sensors that track our body's motion, select our 3D character's avatar, and enter a game. Our interactions in the GMM are just responses to the visual display that we see. We make sensed physical movements in our navigation of the user interface that are unique to the particular GMM experience. The GMM does not care about your emotional state or your mental state as you play against whatever game mechanic has been built for you.

In the HIM, we use biosensors generating data that can be interpreted into physical state, emotional state, and mental state vectors—let's call them *human behavior vectors*. We can take those human behavior vectors and do interesting things with that additional information. We might start with the mental and emotional states of the human player and pass them along to the main artificial intelligence (AI) character. That AI character will have a virtual physical state, a virtual emotional state, a virtual mental state, and a personality and role in the HIM. The AI character will examine the mental and emotional states of the human and generate an appropriate response based on its personality/role/virtual states. For example, if the AI is a pirate in the HIM, its role might be to put the human player off balance: it can compute what to do using the human behavior vectors as intelligence. If the AI is a sensitive character in a well-storied drama, it could use its role and the human behavior vectors as information about how to properly interact with the human player. We go from having only physical engagement (in the GMM) to a HIM that can understand and interact with humans physically, emotionally, and mentally. We have something quite different.

The AI character will examine the mental and emotional states of the human and generate an appropriate response based on its personality/role/virtual states.

So, this all sounds great, but can we do it now? The answer is: we can do some of it but not all of it. There is much research to perform both technically and with respect to design. We can probably build a 1.0 version of the technology now, but if we are going to turn the HIM into a consumer-facing product, then there is significant new design research that must be carried out. We need to research how we draft a design document that utilizes the human behavior vectors generated from our interpretations of the biosignals. To carry out this research, we propose a new laboratory, the Computational Human Perception Laboratory, along with a new degree program, a master's in computational human perception. Now, it is unusual for most universities to create a degree program for a new research direction. Most universities are stovepiped, meaning they have departments whose degree requirements were determined decades earlier. It is hard to make meaningful new research happen with such limitations. Hence, we propose this new degree program to match our research in computational human perception.

COMPUTATIONAL HUMAN PERCEPTION LABORATORY

The focus of the computational human perception laboratory is on creating technologies that can utilize biosignals, signal interpretation, and behavior models for building a HIM, or sensed world. We use the term *sensed world* as a shortcut for "networked virtual

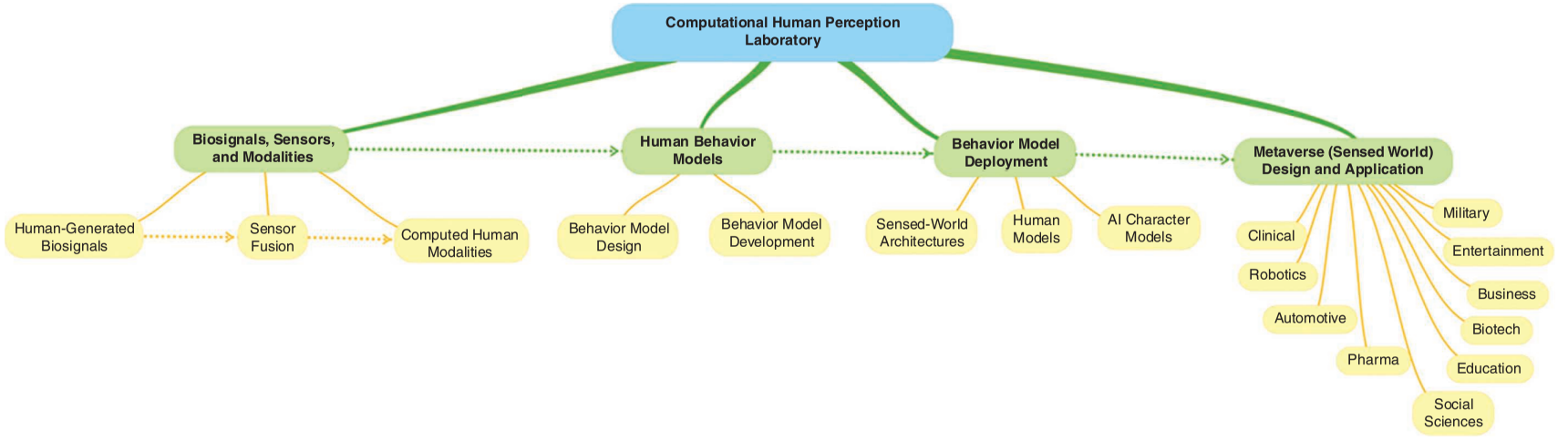

FIGURE 1. The research directions for the Computational Human Perception Laboratory.

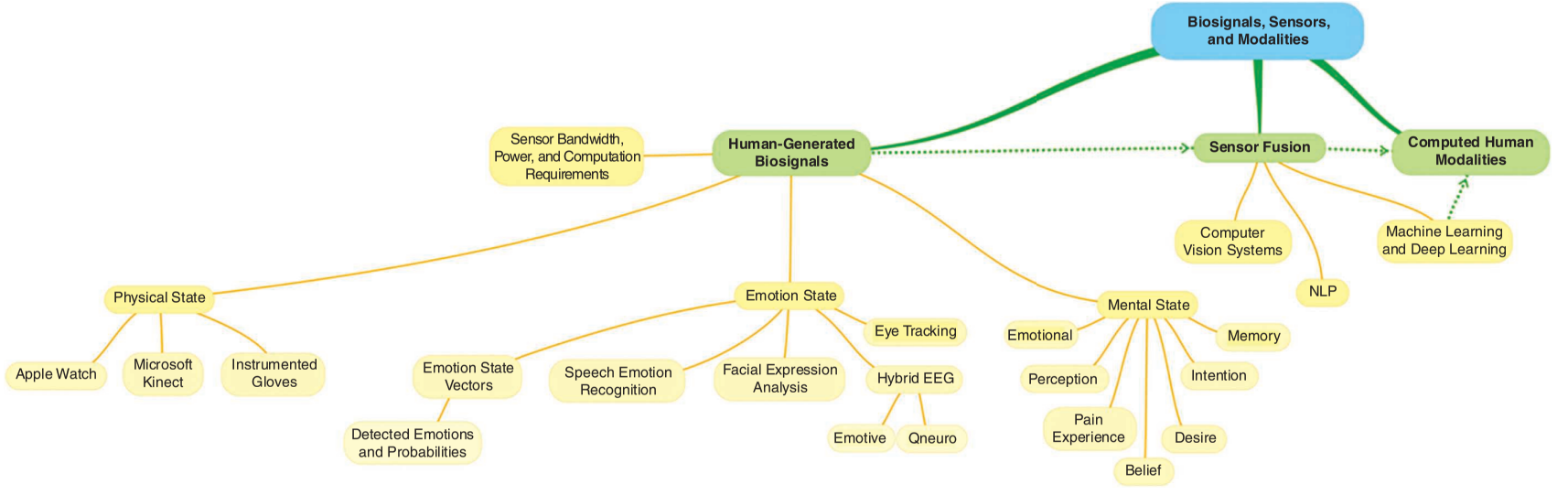

FIGURE 2. The topics for the biosignals, sensors, and modalities course. NLP: natural language processing; EEG: electroencephalography.

world fully infused with sensors." This metaverse will understand human physical, emotional, and mental states as sensed by and interpreted from biosensors. AI characters interacting with the sensed world will have their own virtual physical, emotional, and mental states that will guide their interactions with humans. This metaverse will be the core of the future of online interactive education, entertainment, and telemedicine as well as many other applications.

RESEARCH DIRECTIONS

Research directions for this laboratory are many. They are depicted in Figure 1 and listed in the following. We provide a list of potential research topics rather than a full explication, as this article has a word limit:

- *biosignals*: neurosensory, biometric, and electrophysiologic; eye tracking; facial expressions from cameras; and development of low-cost, high-accuracy biosensors
- *biosensor interpretation tools*: real-time machine learning tools for interpreting physical, emotional, and mental states obtained from biosensors
- *human behavior models*: software models for engagement, performance, emotion, fatigue, comprehension, stress, workloads, and mental states and that can interpret signals from biosensors
- *behavior model deployment*: sensed-world (Metaverse) architectures that can be rapidly deployed with interpreted behavior models for human and AI characters, on augmented reality (AR), virtual reality (VR), extended reality (XR), and gaming platforms
- *interactive experience design*: research on the principles of interactive designs that utilize interpreted biosensors and behavior models in the sensed world (the

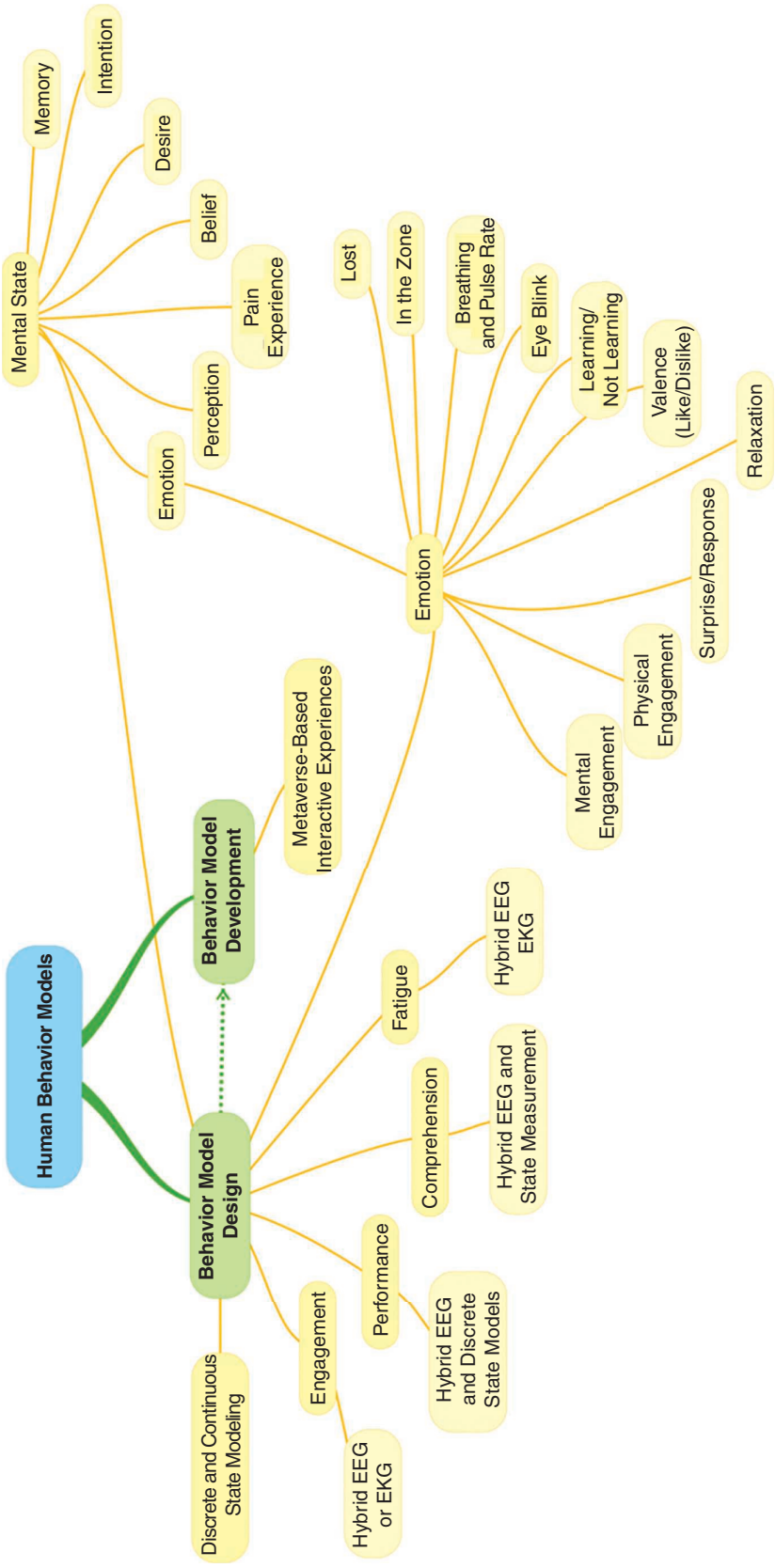

FIGURE 3. The topics for the human behavior models course. EKG: electrocardiography.

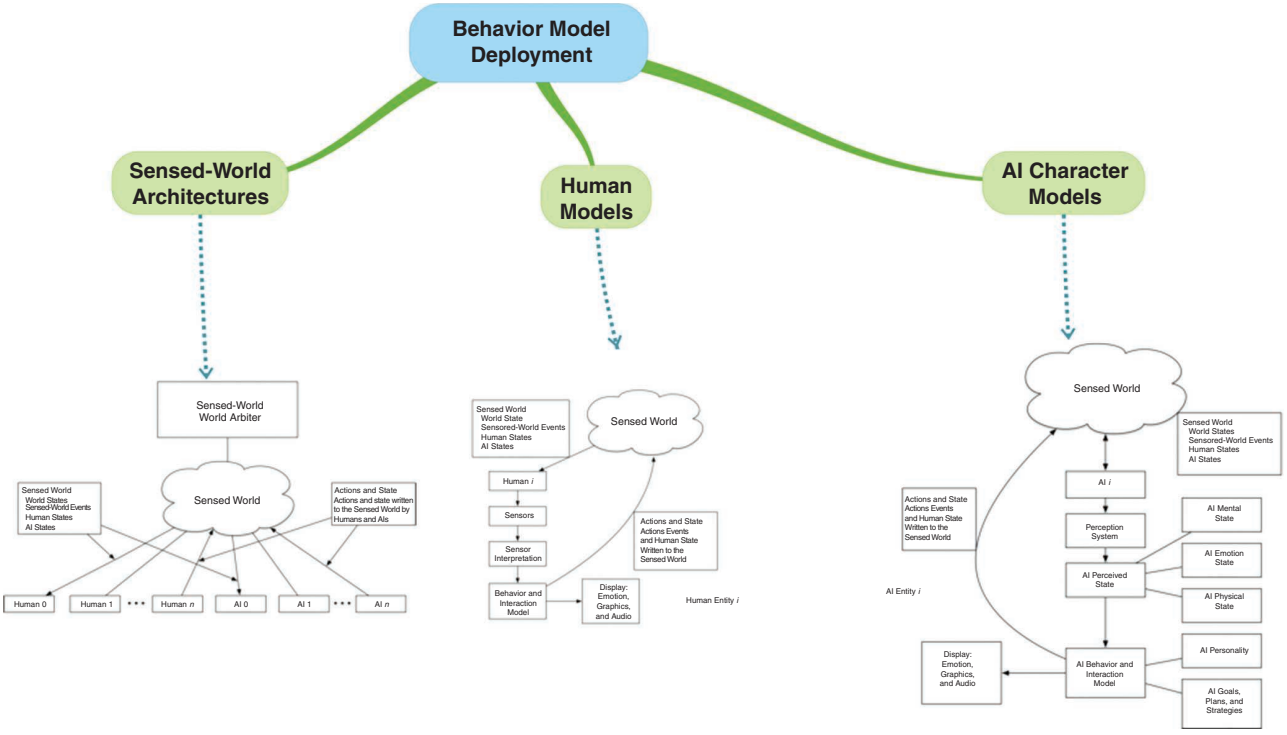

FIGURE 4. The topics for the behavior model deployment course. (See Figures 5–7 for enlarged figure type.)

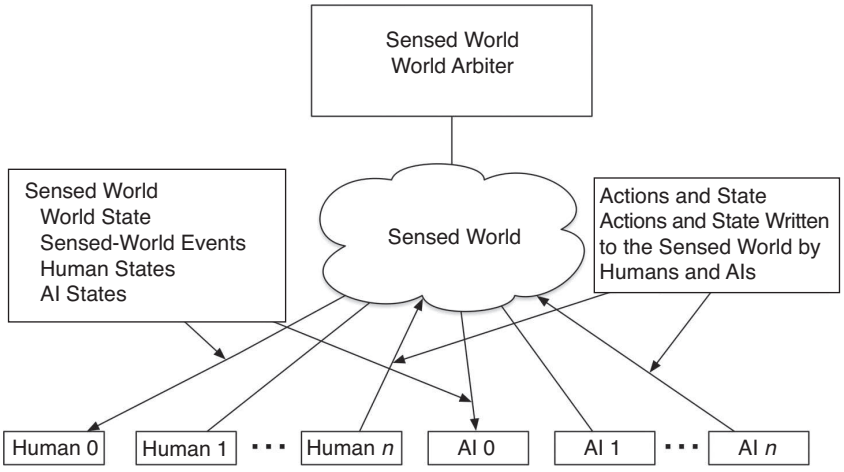

FIGURE 5. The high-level concept for a networked sensed-world architecture.

Metaverse), with display and interaction occurring on the various technological devices used in the metaverse, including AR/VR/XR headsets, mobile phones/tablets, and other wearables/portables, and a focus on interactive experience development for formal and entertainment purposes

- *application*: clinical, entertainment, and education as well as any application to interact with sensed humans and AI characters inside of a sensed and bounded metaverse.

MASTER'S IN COMPUTATIONAL HUMAN PERCEPTION

To support the Computational Human Perception Laboratory research directions, we propose a master's in computational human perception, with the following courses. Each course's text description is followed by a mind map detailing the material to be covered:

- *Biosignals, sensors, and modalities*: The purpose of this course (Figure 2) is to provide an understanding of the available biosignals generated by humans, sensors that can read those biosignals, and human modalities that can be computed from biosignals. Topics covered include human-generated biosignals; emotion states; emotion sensors and computational models for interpretation; emotional state vectors; detected emotions and probabilities; sensor bandwidth, power, and computation requirements; physical state sensors and their computational models; mental state sensors and their computational models; sensor fusion; machine learning for computing human states and modalities

from sensed biosignals; and computed human modalities.

- *Human behavior models*: The purpose of this course (Figure 3) is to teach the principles of human behavior model design and the development of models for metaverse-based interactive experiences. Particular foci will be on models of engagement, performance, emotion, fatigue, comprehension, stress, workloads, and mental states.
- *Behavior model deployment*: The purpose of this course (Figure 4) is to deploy sensed-world architectures, human models (physical, emotional, and mental), and AI character models (virtual physical, emotional, and mental) in metaverse-based interactive experiences and applications. Sensed-world architectures (Figure 5) are the networked software architectures that provide communication among humans and AI characters. There is a software twin of a live human (Figure 6), including physical, emotional, and mental states read from sensors and their interpretations. AI character models (Figure 7) are pieces of software that have virtual sensors that operate in the sensed world such that AI characters can have virtual physical, emotional, and mental states that interoperate with a human state and the characteristics of the sensed world.
- *Interactive experience design*: The purpose of this course (Figure 8) is to teach the principles of interactive design that utilizes interpreted biosensors and behavior models in the sensed world (the metaverse), with display and interaction occurring on various devices. The design focus will be on interactive experience development for formal and entertainment purposes.

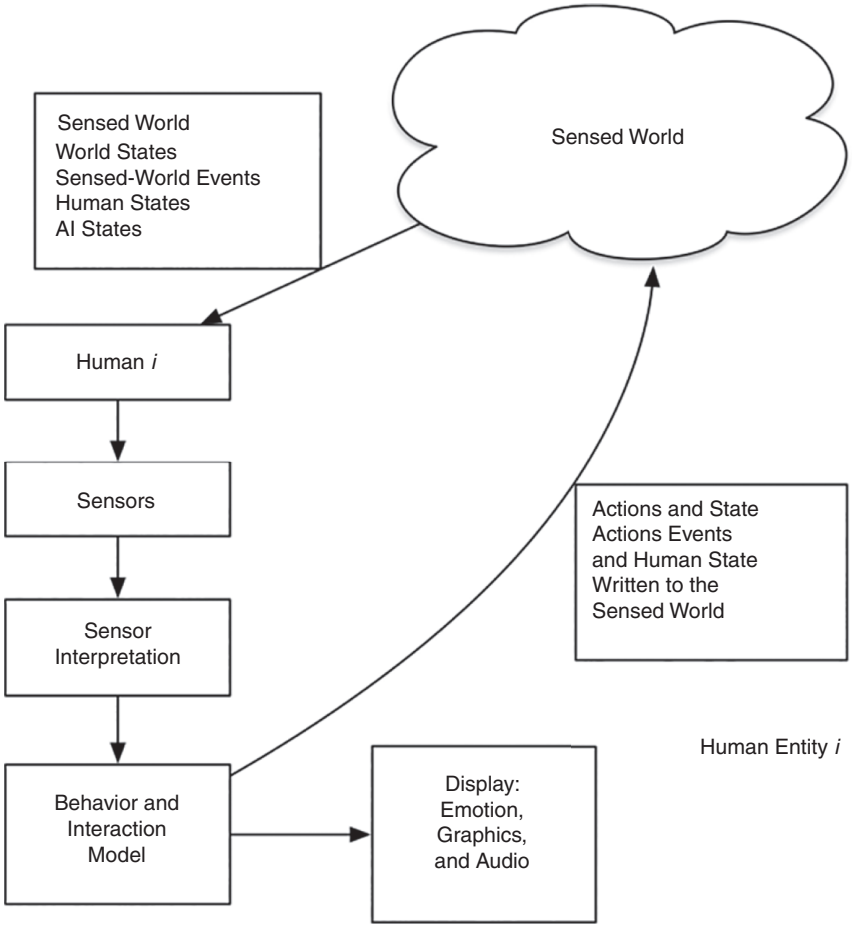

FIGURE 6. The conceptual architecture for human entity *i*.

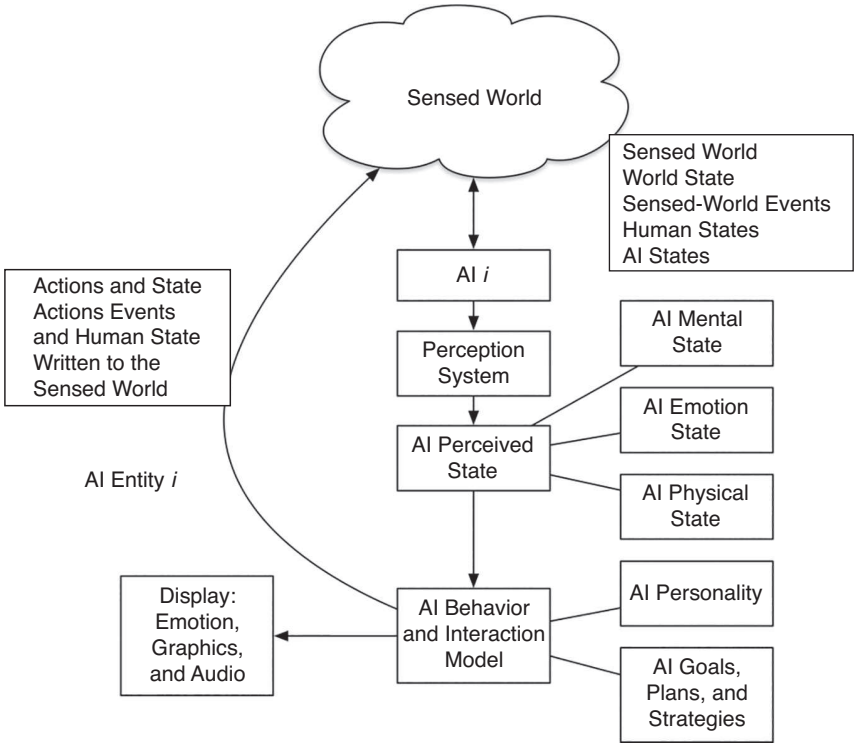

FIGURE 7. The conceptual architecture for AI entity *i*.

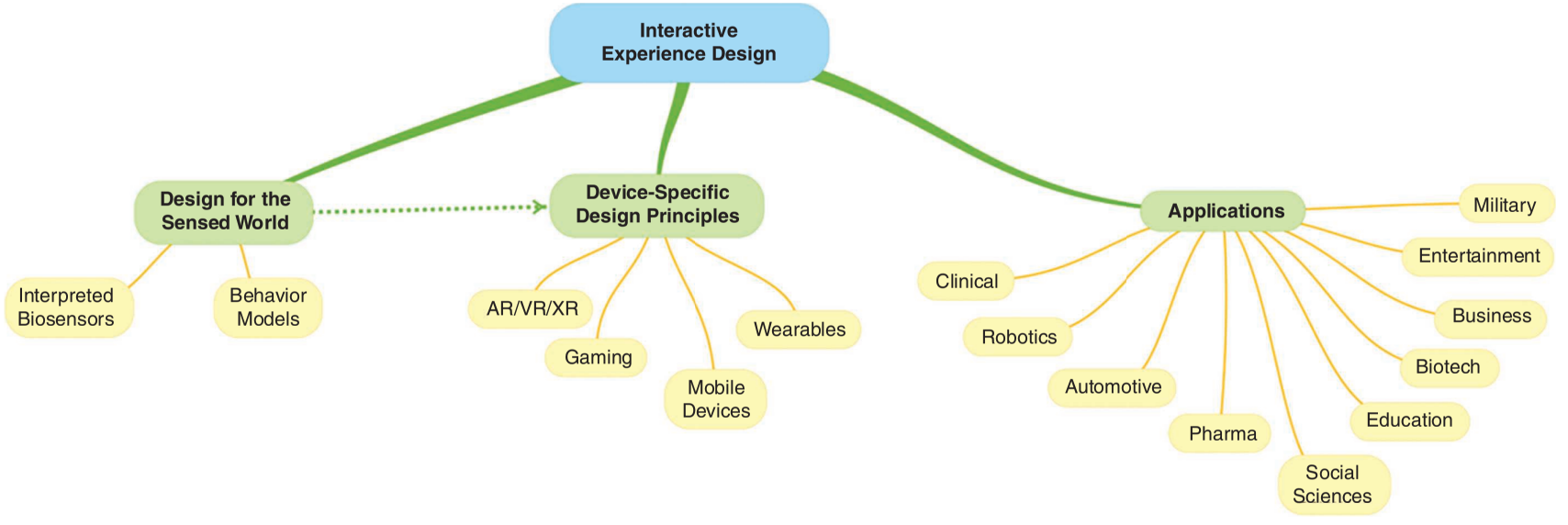

FIGURE 8. The topics for the interactive experience design course.

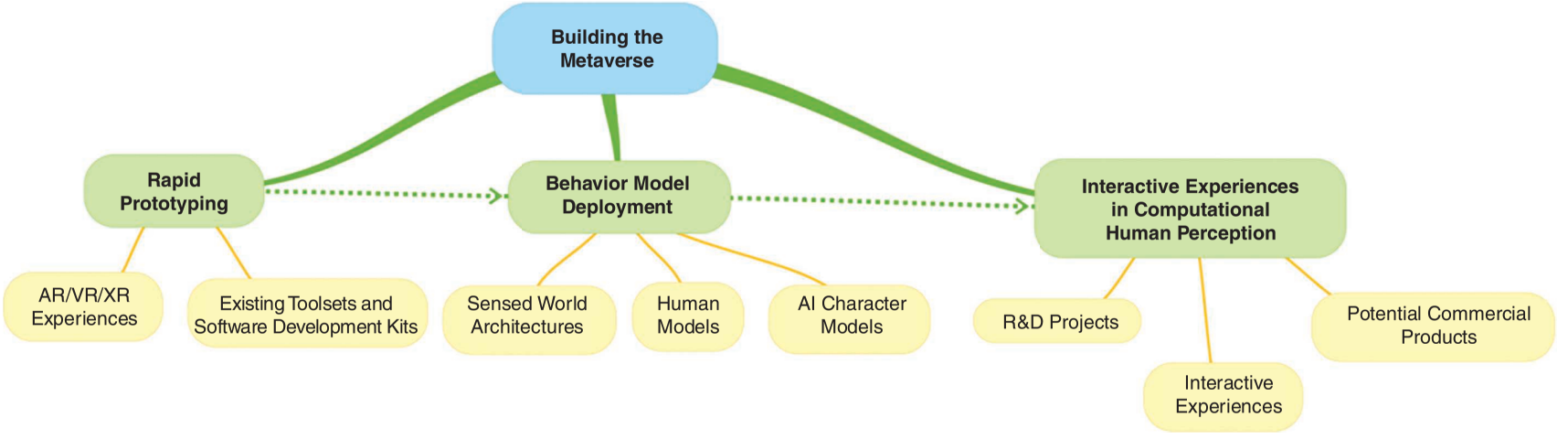

FIGURE 9. The topics for the building-the-metaverse course.

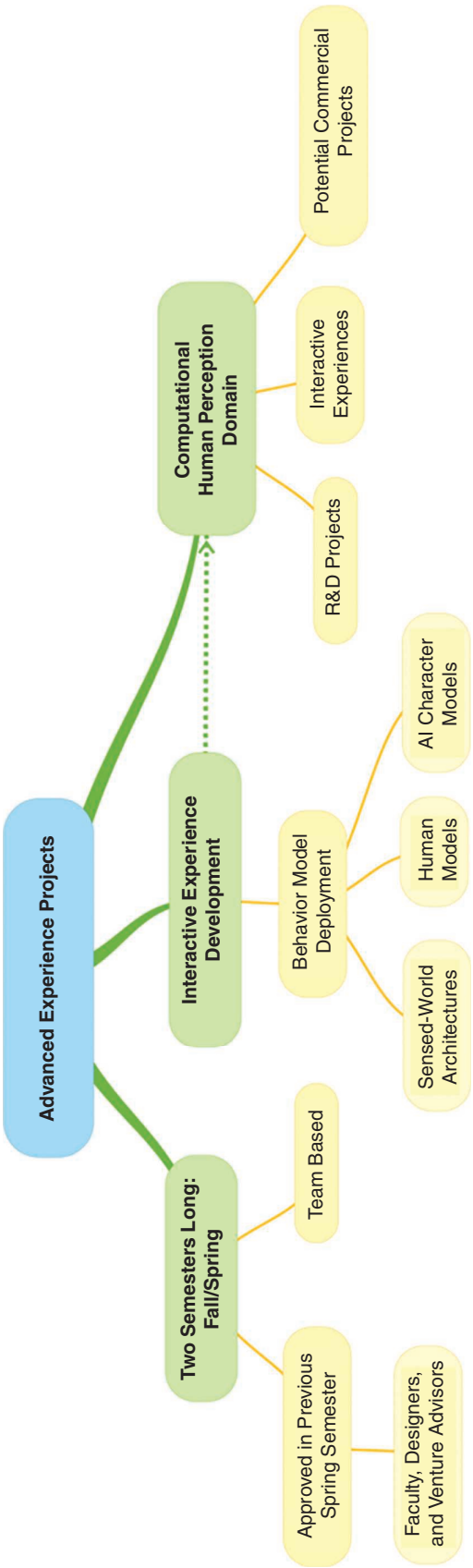

FIGURE 10. The organization of topics for the advanced experience projects course.

COMMENTS?

If you have comments about this article, or topics or references I should have cited or you want to rant back to me on why what I say is nonsense, I want to hear. Every time we finish one of these columns, and it goes to print, what I'm going to do is get it up online and maybe point to it at my Facebook (mikezyda) and my LinkedIn (mikezyda) pages so that I can receive comments from you. Maybe we'll react to some of those comments in future columns or online to enlighten you in real time! This is the "Games" column. You have a wonderful day!

- *Building the metaverse*: The purpose of this course (Figure 9) is to have students rapidly build virtual and augmented sensed-world (metaverse) experiences by using existing toolsets and software development kits. The experiences will be rapid prototypes of interactive experiences that focus on R&D with respect to computational human perception, interactive experiences, and potential commercial products in/related to a domain. Key to this course will be the utilization and deployment of behavior models for human and AI characters as well as bounded sensed-world architectures.
- *Advanced experience projects*: This is a two-semester course (Figure 10) that focuses on team-based interactive experience development utilizing interpreted biosignals, behavior models that employ those biosignals for human and AI characters, and bounded sensed-world architectures. Projects proposed for this course are approved in the spring semester by a committee of faculty, designers, and venture advisors.

In this article, I outlined, in the most appropriate sense of the meaning of *outlined*, a potential research agenda for computational human perception and its potential to be the core for the creation of a HIM. This is not at all the same as the GMM currently being touted to the venture capital community. The creation of a HIM, a sensed world that reaches out from computational infrastructure and interacts with our physical, emotional, and mental states, is part of the future for humanity. Part of this proposal can be prototyped now. Much of it is farther away but absolutely worth reaching out for if we wish to obtain a world where machines understand and interact with us more deeply than now. C

ACKNOWLEDGMENTS

The author wishes to acknowledge research friends for their responses to an earlier draft of this article. Dennis McBride, a former DARPA program manager of mine and colleague for some several decades, wrote back and said, "A program after my own heart ... Computational perception is the bomb!" which I happily received. Rudy Darken, a colleague of mine at the Naval Postgraduate School

and former director of the Modeling Virtual Environments and Simulation Institute, gave me a detailed read and commentary on how to improve what I proposed. I integrated all his suggestions. Rudy wished me well on finding a home for this proposed research and educational program. Khizer Khaderi, Stanford University, started talking with me about creating such a program, beginning in 2005, when he arrived at the University of Southern California. I wrote the initial draft for the degree program as a distinguished collaborator to Stanford's laboratory, but the plan for the degree has not gone anywhere. Maybe it will someday.

> We propose a new laboratory, the Computational Human Perception Laboratory, along with a new degree program, a master's in computational human perception.

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MICHAEL ZYDA is the founding director of the Computer Science Games Program and a professor of engineering practice in the Department of Computer Science, University of Southern California, Los Angeles, California, 90089, USA. Contact him at zyda@mikezyda.com.

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