

# Personalized Health and Wellness: A Vision for The Next Decade

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Imagine you're suffering from depressive symptoms. While your doctor has prescribed you antidepressants and psychotherapy before, they've had limited effect. Frustrated, you consult Google and find a thread on a forum that describes cerebral hypoperfusion, how it might be causing your symptoms, and how exercise can improve them. So, you get a fitness tracker and run a self-experiment to track your symptoms before and after exercise. While exercise helps, it still can't keep the depressive episodes at bay. So, you Google again and find that your symptoms show up in people suffering from heavy metal toxicity. To test this, you begin another self-experiment by clearing out potential sources of exposure, undertaking detoxification protocols, and seeking out chelation therapy. While this also seems to help, it fails to provide full relief. Back to Google you go. Is it a mineral imbalance like copper overload? Try a zinc and magnesium supplement. Is it a leaky blood-brain barrier? Try a gluten-free diet and increase your Vitamin D intake. Is it an autoimmune condition producing antibodies against the brain? Try reducing your exposure to mold, pesticides, and allergenic foods. Is it chronic inflammation and a dysfunctional stress response? Try mindfulness meditation and neurofeedback. Is it constant blood-sugar dysregulation and insulin resistance in the brain? Try nutritional ketosis. Is it undermethylation or high levels of histamine? Try methionine. Is it overmethylation? Try Vitamin B3 and B12. Is it a bit overwhelming? Likely for both you and your physician.

Now, imagine yourself suffering from the same onset of symptoms 10 years from now. You decide to turn on the mHealth application on your phone to ferret out possible causes for your condition. Perhaps it is set up to monitor your cerebral blood flow using an HEG sensor embedded on your skin. Perhaps it monitors your exposure to toxins or your breath ketones using an embedded air sensor. Perhaps it checks for copper overload by using your phone's camera to capture images of your eye. Perhaps it monitors your stress response to food and the environment via heart-rate variability using a sensor in your watch. Perhaps it monitors your level of fatigue and inflammation using a cortisol saliva test. Perhaps it monitors your blood sugar and histamine levels using a transdermal patch. After gathering as much epigenetic and diagnostic information as it can, you set the application up with your genomic profile and send it off to search for other users of mHealth who share similar genetic and epigenetic markers as you and have also experienced depression. You discover that you have genetic similarity to several users that suffer from silent celiac disease. Using the mHealth app's medically-driven social network, you connect to the network of those interested in silent celiac disease. From this, you get daily pointers to articles on how best to implement a gluten-free lifestyle. One of the articles guides you on how to configure the mHealth app's programmable self-experiment framework to track whether gluten consumption impacts your symptoms. After running the experiment for several weeks, your brain fog seems to lift and you begin to feel better. You upload your self-experiment to mHealth's backend database so that subsequent users can see your result. Returning to the mHealth network, you come across a citizen-scientist using the mHealth app to find participants in his study for reducing depression symptoms using histamine-degrading strains of probiotics. You decide to participate and download the scientist's self-experiment plug-in for your mHealth app to conduct his trial on probiotics and depression. The mHealth plug-in guides you on how to measure the strains of bacteria in your gut flora before you start, sends you daily reminders to take the probiotic, prompts you periodically for the severity of your symptoms, and asks you to measure your gut flora upon completion. When the study finishes, your results are anonymized by the mHealth app so that it can be included in the scientist's study. The study is wildly successful and the combination of a gluten-free diet and probiotics quickly becomes a viable treatment for your condition. You decide to 'Like' the study and its protocol within the mHealth app. As people try it out

and provide their own feedback, the protocol is validated and instantly shows up as a recommended intervention for those with similar symptoms and profiles.

The narrative above is an attempt to highlight several emerging trends that are happening in health and wellness. The first is the explosion of information and research on epigenetics and bioindividuality. Interventions must not only take into account the unique genetic makeup of an individual, but also their epigenetic expression. That is, which genes have been turned on. Additionally, the genetic makeup of viruses, cancer, and the gut flora are now being shown to have huge impact on the course of treatment to take. These traits must be measured in-situ and their uniqueness forces an individual to seek out cases that are most similar to theirs so that they can analyze the outcomes of interventions others have pursued. Another trend is that science and medicine is revealing the complex interconnectedness of our gastrointestinal, detoxification, immune, endocrine, cardiovascular, and musculoskeletal systems. As the body of knowledge explodes, it is becoming extremely difficult for individual doctors to keep up with all of it. For example, unless doctors dig deeply, they are only able to treat depressive symptoms as nothing more than a Prozac deficiency. Rather than relying on the silo of an individual doctor, it is envisioned that future healthcare will look more like a targeted search for expertise most related to the patient and his/her symptoms and epigenetic state. The third trend that the narrative highlights is the democratization of knowledge and research in health care. Open access to medical journals and data sets, burgeoning web sites and forums across the gamut of health topics, and the ability to perform and report individual experiences with specific interventions is empowering people to help themselves and each other directly with their health issues. With all of these trends, we believe computing technology developed by this community of researchers will play an essential role.

Specifically, we believe there is an opportunity for advances in the following areas:

- Extensible platforms for integrating biosensor information
- Leveraging genetic and epigenetic data to improve diagnostic accuracy
- Privacy-preserving, medically-driven social networks for crowd-sourced health care
- Flexible software for running arbitrary self-experiments
- Platforms for enabling citizen science
- Collaborative filtering and recommendation systems for ranking interventions
- Improving compliance, accuracy, and tamper-resistance of epidemiological trials
- Flexible software for running arbitrary self-experiments
- Turning massive collections of data into concise actionable information

Nirupama Bulusu will serve as the lead proposer for the workshop.

About the proposers:

Nirupama Bulusu is an Associate Professor of Computer Science in the Intel Systems and Networking Laboratory at Portland State University. She has an interest in adapting next generation computing technologies to address critical societal problems, encompassing environmental sensing, urban planning and health. She is a recipient of the National Science Foundation CAREER award and was a participant at the 2013 mHealth Training Institute.

Wu-chang Feng is a Professor of Computer Science in the Intel Systems and Networking Laboratory at Portland State University where he leads an active research group in computer systems and security. Prior to this position, he was an Assistant Professor at Oregon Health and Science University. After recently discovering and using a variety of techniques to improve his own mental and physical health, his current research interest lies in developing technology to help others do the same.