Media Lab Focus: New Health
The MIT Media Lab promotes an interdisciplinary research culture that brings together diverse areas of interest and inquiry. Art, science, design, and technology build and play off one another in an environment designed for collaboration and inspiration. Our faculty, students, and researchers work together on hundreds of projects across disciplines as diverse as novel materials, conformable sensor platforms, artificial intelligence, data visualization, privacy and cryptocurrency research, new models and tools for learning and community building, and sustainable cities. The Lab's unique research culture is reflected in the broad spectrum of projects supported by Member Companies.

In this report, we highlight projects that look into New Health - new ways to look at the overall wellbeing of an individual.

**Opera of the Future**

For more than 20 years, the Opera of the Future group has been devoted to finding ways to use music and audio to enhance health and wellbeing, as well as to diagnose and treat disease. A first phase of our work involved the creation of musical tools and techniques to improve communication and expression for those on the autism spectrum or with limited physical mobility, leading to a comprehensive theory of music, mind, and health. A second phase of research explored the potential of the voice as a platform for healing meditation, for interpersonal/interpecies communication, and for treating such health conditions as stuttering. Most recently, Opera of the Future has been researching the potential for audio to enhance brain function, collaborating with MIT’s Li-Huei Tsai and Ed Boyden on the use of 40 Hz Gamma frequencies to stimulate microglial cells, potentially reversing the effects of Alzheimer’s disease. Prof. Tod Machover has demonstrated that such Gamma signals can be embedded in musical compositions that may deliver therapeutic benefits while providing emotionally rich, acoustically attractive, concentration-inducing experiences. Recent performances and recordings by the Kronos Quartet and soprano Renée Fleming—in works such as Gammified and VocaGammified—have widely disseminated these sounds and techniques to both professional and nonprofessional publics.

Opera of the Future is also making research strides in creating new musical tools for medical intervention. In collaboration with Massachusetts General Hospital’s Vascular Neurology department, the goal is to support physicians as they provide care and rehabilitation to their patients, either in person or remotely. The development of first-of-their-kind MediMusical Instruments leverages the inherent musical properties of traditional instruments, while each device is imbued with medically oriented functionalities and sensors. This allows the devices to operate as portable sensory platforms, converging some of the most essential qualities of both medical and musical instruments to support treatment. During the Covid-19 pandemic, we made further progress in prototyping and developing these systems for remote patient care. These devices can now amplify telehealth visits to near in-person efficacy by allowing for manual, sensory, and kinetic engagement through interactive, musically rich experiences, while garnering vital numerical data. MediMusical instruments provide diagnosticians with powerful tools, physicians with data-driven and efficacious devices, and patients with more effective and rewarding treatments.

**Conformable Decoders**

We live in an ocean of physical patterns: heartbeats, respiration, muscle movements, neural activity, tidal waves, airflow, ambient humidity, temperature change. These patterns contain information—coded messages—that needs to be excavated, refined, and defined; to do so, we need sophisticated interfaces to effectively access and evaluate such information. The Conformable Decoders group explores novel materials, device designs, and fabrication strategies to create micro- and nanoscale electromechanical systems with mechanically adaptive features, which allow intimate integration with the objects of interest.
Media Lab Focus: New Health

With cFaCES, we show that piezoelectric thin films, coupled with algorithms for the real-time detection and classification of distinct skin-deformation signatures, enable the reliable decoding of facial movements in healthy individuals and in patients with amyotrophic lateral sclerosis (ALS).

Through E-TeCS, we introduce a new platform of modular, conformable (i.e., flexible and stretchable) distributed sensor networks that can be embedded into digitally knit textiles. This platform can be customized for various forms, sizes, and functions using standard, accessible, and high-throughput textile manufacturing and garment patterning techniques.

We have also developed MiNDS, an implantable, remotely controllable, miniaturized neural drug delivery system permitting dynamic adjustment of therapy with pinpoint spatial accuracy. We demonstrate that this device can chemically modulate local neuronal activity in small-animal (rodent) and large-animal (nonhuman primate) models, while simultaneously allowing the recording of neural activity to enable feedback control.

Fluid Interfaces

Good sleep habits are seminal for mental health. Sleep issues are comorbid with mood disorders, memory and attention problems, and with weakened immunity, heart health, obesity, cancer, and more. A new wave of electronics make laboratory-based sleep aids available at home, which may improve health and daytime performance in significant ways. Fascia is a smart sleep mask aimed at facilitating sleep studies in natural settings. The prototype is designed to maximize the quantity and quality of sensor signals, as well as ensuring user comfort, so as to produce accurate data and reduce the first night effect typical of clinical sleep studies. The prototype can also detect emotional expression via facial EMG, which presents a possibility for recording emotional expressions to a dream avatar, as prior research has demonstrated that frowning and smiling muscle tension during sleep corresponds with dreamed emotional content (Rivera-García et al., 2019).

Most of the commercial devices available today are focused solely on monitoring sleep, including measuring sleep duration, sleep stages, and breathing patterns during sleep. There is an opportunity to go beyond monitoring data during sleep to creation of devices that intervene in sleep to improve sleep onset, quality, and duration, or enable new sleep applications. Dormio is a sleep stage tracking system accompanied by an interactive social robot that is able to influence, extract information from, and extend hypnagogic microdreams, which is a semi-lucid sleep state characterized by phenomenological unpredictability, distorted perception of space and time, and spontaneous, fluid idea association.

Affective Computing

Too often, people wait for anxiety and depression to become severe before seeking diagnosis and treatment, making the disorders more difficult to treat, reducing the likelihood of success, and increasing the damaging toll on their families and lives, as well as their medical costs. We wish to show that it is possible, using technology, to catch the downward slide early and begin treating it before it becomes disruptive enough to receive a traditional diagnosis—in other words, we believe that prevention is possible. ELSA is an AI-powered chatbot that acts as an empathetic companion, encouraging users to talk about their day...
through a form of interactive journaling. More specifically, we build hierarchical recurrent neural network models that can converse like people and use transfer learning of topic and emotional tone recognition models to improve our final model. The Guardians Project aims to use the same game design principles used in mobile games to help people form beneficial long-term habits and improve their overall wellbeing, and to motivate people suffering from depression and anxiety to stick to therapeutic interventions. Ultimately, we’d like to see technology help to cut the rates of depression and anxiety in half globally. Our first choice is to work with a vulnerable population of women with low economic means who are pregnant; improving the outcomes for a pregnant woman over the course of a year will also improve the health outcomes for her child. We will combine the best ideas from positive psychology, affective computing, relational agents, gaming engagement, digital phenotyping, and participant input to craft an intervention that combines smart sensing and engaging techniques.

**Signal Kinetics**

The Signal Kinetics group focuses on inventing, building, and deploying wireless sensor technologies to address complex problems in society, industry, and ecology. Our technical innovations span different aspects of sensor design and engineering - including materials, hardware, signal processing, algorithms, machine learning, and network architectures. Our Cardiovascular Monitoring is a new system that can capture seismocardiogram (SCG) recordings without requiring any contact with the human body. Such an unobtrusive approach would enable lay users to routinely monitor their SCG signals (e.g., on a daily basis), and may provide early warnings of cardiovascular conditions. Our Battery-less Micro-Implant is a fully-integrated wireless and batteryless micro-implanted sensor. The sensor powers up by harvesting energy from wireless signals and communicates at net-zero power. They could be used for continuous monitoring of biomarkers and tumors, ultra-long lasting drug delivery systems (e.g., for patients with Alzheimer’s or Osteoporosis), and closed-loop control systems with real-time feedback (e.g., artificial pancreas for Diabetes’ patients). Our Deep-Tissue Networking is a new technology that can wirelessly power and communicate with tiny devices implanted deep within the human body. Such devices could be used to deliver drugs, monitor conditions inside the body, or treat disease by stimulating the brain with electricity or light. In tests in animals, we showed that the waves can power devices located 10 centimeters deep in tissue, from a distance of one meter.