Drug Overdose Monitoring Device Blueprint

Report Submitted to the Paradigm Challenge

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We propose an in-vivo, untethered capsule equipped with three sensors, a wireless transmission module, and a locomotion mechanism. Doctors and physicians will be able to prescribe this mechanism for their patients. The main features of this microtechnology are to measure drug levels, blood glucose and oxygen levels, and blood pressure. The sensors on the device would perform continuous, real-time monitoring and would send a signal to a smart device to record the data. If the sensors detect excess quantities, they will send notifications/alerts to the doctor and patient via a mobile application that is connected to the device. Especially during COVID-19, health issues such as opioid overdoses are reaching an all-time high and our invention makes it so that patients' conditions are monitored to prevent an overdose, heart attack, or stroke.

We propose an in-vivo, untethered capsule equipped with sensors, a wireless transmission module, and locomotion mechanism. The main features of this microtechnology are to measure blood glucose and oxygen levels, drug levels, and blood pressure. The sensors on the device would perform continuous, real-time monitoring. This data would be stored in the server hosting the web application, and the data would only be visible to the doctor and the patient. If the doctor would like to deactivate the system, he or she could turn on the device feature to exit the patient's body.

To be able to move through the arteries of the body, the capsule must be equipped with microsensors, and the dimensions of the capsules are 375 um long and 35 um diameter. Inspired by the Microfluidic Electrochemical Detector for in vivo Concentrations (MEDIC) technology proposed by the University of California, Santa Barbara, the capsule would have an outer layer made up of gold electrodes with custom microfabricated electrodes. This electromechanical technology can be customly configured to measure different target molecules by changing the type of chemical probe. The target molecules in the blood would bind to the electrochemical redox reporters, which would then allow the capsule to perform the necessary analysis to determine concentration of target molecules, indicating any drug overdose.

The inner layer would be made up of Polyurethane Elastomer due to its high ductility, toughness, and good stability. The waterproof inside of the capsule would house the sensors, the wireless data transfer module, and the micromotors for locomotion. When traveling downwards through the body, the capsule would utilize the blood pressure gradient to move. In this process, the motor would convert the kinetic and potential energy into usable electrical energy, which

would be stored in a capacitor. While the capsule navigates bottom-up through the body, it would actively use its motor for locomotion. Inspired by prokaryotic cell locomotion mechanisms, the capsule would have a micro spiral tubular structure like flagellum, resulting in a maximum speed of 300 um/s. The stator axial vibration combined with stator torsional vibration would result in the capsule's linear motion. To guide the direction of the capsule, a micro-rudder would be attached.

In conclusion, our untethered micro-capsule technology can perform in-vivo fluid measurements including blood glucose and cholesterol level, oxygen levels, and drug levels. This real-time monitoring device can alert the patient and doctors of daily activity and sudden surges or abnormalities. The device would be paired to an app, which would notify the doctor and patient of any irregularities or concerning patterns in the data.

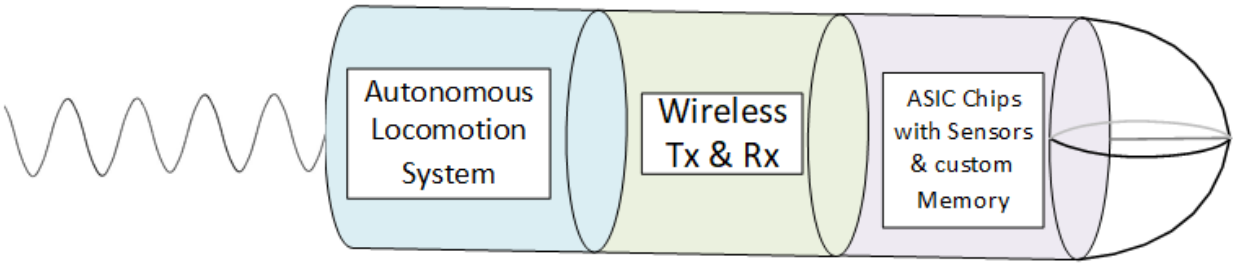
After doing research and learning about how many people with existing conditions such as substance abuse and diabetes are struggling to monitor their physical state and condition especially because of COVID-19, our team wanted to create a device that physicians and doctors could use to track the state of their patient through monitoring levels of drugs and hormones such as insulin. While we originally created the invention to specifically monitor drug levels in the body to prevent overdose, as we researched more into the topic, we believed that the device would be even more helpful if it could be extended to monitoring hormones such as insulin and providing feedback on one's condition/hormone levels if they have diseases such as diabetes.

With collaboration, we were able to split up the research work seamlessly and get the research done faster and more effectively. During our meetings, we were able to build upon each other's ideas. We brainstormed our own solutions, and as a group, choosing the best and most detailed solution. At one point, we had gone through 5 drafts of our idea in order to reach the final product. Through collaboration, we were able to address more aspects of our solution, and in turn, we were able to create a more complete solution. We were also able to collaborate with professionals in telehealth companies who gave us insight into how the device would function if introduced into the healthcare industry. Additionally, getting feedback from these professionals influenced us to build a mobile app that allowed both the doctor and the patient to track the information of the sensor. This allowed us to make our product more connective and effective.

We gained major experience in researching. We also got a feel for specific aspects and questions to answer when pondering on a solution to a problem. We learned a lot about how blood sensors work, signs of drug abuse in the human body, and Machine Learning. Each time we met, we were extremely excited to bounce new ideas off each other and perfect our idea. Most importantly, however, we learned the power of collaboration, and how collaboration, when done right, can noticeably help generate better ideas for society. The experiences we had during

the Paradigm Challenge will be greatly remembered not only for the lessons it provided us in collaboration and teamwork but also for the interest of bettering the world that it inspired in us.

Our team learned about the paradigm challenge through the web as we previously were collaborating together on Hackathons and were interested in other competitions on which we could collaborate together.



Sources:

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