Ai Driven Advanced Internet Of Things (Iotx^2): The Future Seems Irreversibly Connected in Medicine

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The internet of things, or IoT, devices have become an indispensable part of the modern world. Today, billions of devices are internet-connected and 50 billion more are coming (Fig. 1) (1). Moreover, every new technology or gadget evolves and grows through a strong interaction with the internet and produces an elaborate IoT network. This emerging smart network has already permeated nearly all aspects of our modern life and has an amazing ability to collect, analyze, and distribute vital information, especially in the healthcare platform.

The IoT network has already opened up various possibilities in medicine and is certain to emerge even more when it is driven by artificial intelligence (AI). Today, AI driven IoT networks can track the smallest of details and every encounter with a healthcare provider efficiently and effectively to improve patient monitoring, diagnosis, early cancer detection, post cancer treatment, follow-up care, etc. Even though it may appear we have made important leaps and technological advancements, we are still in a primitive age of AI driven IoT networks. For example, smartwatches, fitness trackers, and other wearable smart devices only track certain features, like heart rate, sleep activity, workout, etc. If you would like to track respiratory rate, postural analysis, blood pressure, etc., you need to wear multiple individual devices, specific to each individual function. Today, it is impossible to track every motion with a single gadget, which is an important limiting factor to getting a complete understanding of a person's medical status. In medical fields, we can connect every input to identify or recognize health risks or behavior changes. For instance, we do not have any IoT device yet to track physical movement patterns such as rubbing your eyes, crossing your legs, abnormal twitches and ticks, etc. in a one single practical hardware. Additionally, it is illogical and not practical to carry a IoT device for each of these individual movement behaviors.

Moreover, all these IoT devices are also hardware limited and only give a fraction of a person's physical well-being, rather than continuous monitoring. These devices strongly rely on battery life, hardware performance, and network operation efficiency, which requires them to be dependent on users' motivators and intentions. Your average typical user will get insufficient readings due to inconsistent usage, thus it will be more challenging to identify health issues and medical changes in a person, making these IoT devices irrelevant. Every IoT device user has experienced similar irrelevance through their past experiences.

Knowing these limitations, how can we achieve an advanced IoT network with battery-free, multifunctional, and cheap IoT devices, for the future, to enable accurate continuous health monitoring, point-of-care diagnostics, and real time evolutions, while decreasing responsibility of the user? Answering this question will present an advanced AI driven IoT network (IoTX^2) that the world has never seen before.

The fundamentals for making IoTX^2 devices will mainly rely on wireless and nanotechnology, as well as, state of the art AI algorithms. An effective and scalable IoTX^2 network can only be formed if all three of these pillars work together. Today, we have novice tools combining to make sense of the wireless information by using AI, such as monitoring vital signs without requiring any physical contact or gadget (2-9). However, feasibility of breathing and heart rate monitoring without direct contact is very challenging and inefficient at providing accurate and reliable data. Today, most of the approaches, such as doppler and localization techniques, require a person to be very still and in

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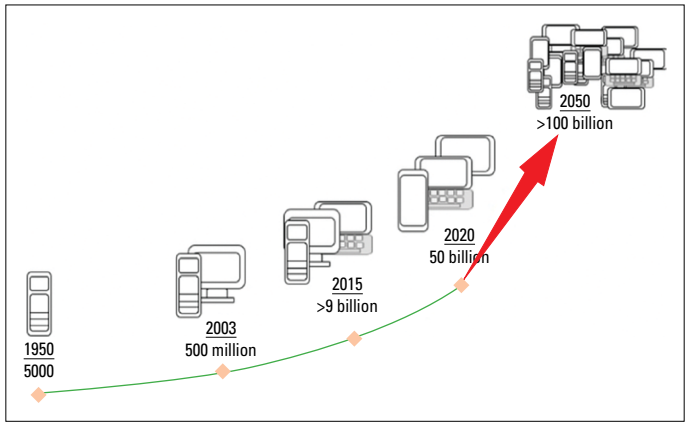

Figure 1. Growing number of connected devices

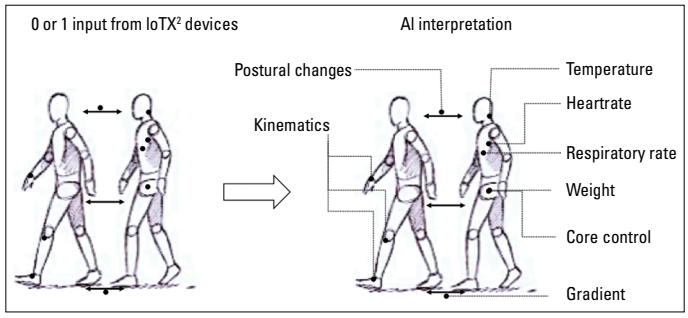

Figure 2. Making sense of wireless signals through IoTX² network. Simultaneous data collection and multiple AI interpretation for practical use in real time

close proximity to get a correct analysis (4-9). There are only a very few studies that can track vital signs simultaneously in-situ but they also suffer from monitoring range, signal variation due to full body motion, and/or non-human motion (9). To overcome all these limitations, it is very critical to combine this approach with nanotechnology to create the IoTX² for the future. With nanotechnology, we can arrange nanoparticles with such precision, programmable matter, that any material objects can be used to gather information. For example, it is possible to develop zero-power nanostructured antennas that can be deployed everywhere, from clothing to body lotion. These antennas can be designed in such a way that they can absorb or reflect the ambient wireless signals to send data via backscattering. Thus, they can report any physical changes, due to heat, vibration, electromagnetic or acoustic alteration, etc. When they experience any alterations due to these physical changes, wireless devices sense this feedback through AI algorithms as a 0 or a 1 without needing any battery or electronic. These signals then can be analyzed by more sophisticated AI algorithms to provide purpose or meaning to the data. In this way, every surface or fabric can be turned into a smart device, a sensor, that can provide consistent and reliable information (Fig. 2).

Achieving this combination is key to the success of the IoTX² network. With this network, we can continuously track even the smallest of movements of a user. This will be revolutionary in the field of medicine, specifically in preventative care. Here are a few examples of how this could impact healthcare:

i. Prevention of work related injuries: ergonomic assessment, work station assessment, is very critical today to minimize injury and maximize productivity. Enterprises even lose billions of dollars in workers comp claims every year. With the IoTX² network, we can go beyond the typical assessments, like monitor height and chair position to understanding specific subtle or repetitive key movements and postural abnormalities thought the workday. Basically, the person can track their own unconscious movement patterns and identify potential areas of risk. Thus, injuries can be prevented before even happening.
ii. Understanding movement patterns and potential cause of diagnosis: today, we do not have a universal system that can track patients' behavior to assist in diagnosis or treatment. At best, we request patients to track their own behavior and report back. However, we know this information is often subjective, incomplete, or false. This has the potential to lead to misdiagnosis and a trial and error method for treatment course. With the IoTX² network, we can achieve continuous and accurate behavior assessments to increase accurate diagnosis and eliminate a trial and error approach to treatment. We may even be able to track unidentified patterns that could assist in preventative medicine for other patients. For example, with patients who are identified as high risk for a cerebrovascular accident or myocardial infarction, we can provide continuous monitoring of heart rate, respiratory rate, blood pressure, temperature, etc. without patients needing any hardware to monitor. In the case of drastic changes, physicians can even be immediately informed of changes in the patients' health status to prevent life threatening conditions. These examples can be elaborated further to tune to the needs of every field of medicine from monitoring more chronic medical conditions such as eating habits in patients with gastrointestinal conditions to observing basic activities of daily living such as movement patterns of high risk infants with delayed milestones.

Gathering all this information from the IoTX² network with maximum security to maintain patient privacy is more achievable than any other current technology. Because, this data can be collected in such a way that AI algorithms can personalize the data to each individual to insure patient identifiers are only known to the patient and their healthcare providers. When this IoTX² network is established, this will lead to the creation of an elaborate database throughout the world, that will provide a gateway to a revolutionary path in the field of medicine. It will identify valuable patterns that will prevent and potentially extinguish certain diseases or diagnoses.

Conflict of interest: None declared.

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