The voices of patients in need

Dr Shinichi Tokuno discusses his vision for increasing the efficiency of healthcare by developing smartphone technology that recognises vocal patterns linked to stress disorders, thus providing early diagnosis and quicker treatment

Your work is built in part on the idea that Japanese citizens need to take more responsibility for their own health. Can you explain why and how your project using a voice-based health status monitoring system can play a role?

Despite a good system of health insurance in Japan, there is still a problem in society with increasing medical expenses accompanying ageing. Therefore, there is a need to promote health solutions that begin in the home before medical treatment is necessary. Promoting health at home involves personal behaviour change and for that purpose we need easy-to-use equipment that continuously monitors patients and issues alerts where necessary. Our equipment uses voice emotion recognition. This technology can infer the speaker's emotions from patterns of changes in fundamental frequencies of the voice. In this way, a number of emotional conditions such as depression can be monitored from in the home.

How does your app, the MIMOSYS: Mind Monitoring System, translate the changes in voice characteristics into an in-depth understanding of the mental health of a person?

Since the expression of emotion is lowered due to stress load and depressive symptoms, it is possible to understand the degree of stress and depression by monitoring emotion. We therefore attempted to assess stress intensity using vocal emotion recognition technology through a computer program. In a verification study comparing our program with assessments through self-administered questionnaires and interview assessments, the proposed technology obtained almost the same detection sensitivity as the questionnaires and interviews.

Could you explain what reporting bias is, why it is a problem for current diagnostic methods and how the vocal emotion technology is able to avoid such bias?

Reporting bias is the tendency of patients to underestimate or overestimate their own behaviour in response to a question, which are currently how most mental disorders are diagnosed. This bias can be done consciously or unconsciously. For example, when a doctor asks about alcohol intake, many people answer less than the actual amount. In fact, it is often reported that the detection rate decreases in an organisation with a high hierarchy in screening by self-written responses to questions. Since the changes in a patient's voice are an autonomic reaction with origins in the nerve system, it is involuntary and cannot be controlled by oneself. Therefore, voice change is a more objective way to gain information and avoids reporting bias.

How will the benefits of your new system filter through to people on the ground?

In recent years, the use of vocal commands to operate equipment has increased. This indicates an increase in the opportunity to acquire voice data. This data can then be useful for diagnosing mental disorders resulting from stress. Certain disorders can alter the expression of emotion and cause changes in certain voice qualities. If we consider that diseases like depression, Parkinson's disease, dementia, schizophrenia and autism alone have more than 10 million patients worldwide; one can see the benefit our voice-based health status monitoring system can have. I dream of enabling people to promote their health and to seek out medical treatment early via speech analysis. In the near future, it may be possible that by using vocal commands to start the engine of a car, for example, your car might also recommend that you go to the hospital. ▶

Taking health into our own hands

Ageing populations and increasing levels of mental illness are putting a strain on health infrastructure, making the need for citizens to take responsibility for their own health all the more pressing. To do so, new technology is needed for us to monitor our own well-being quickly, easily and accurately

Early detection of a health issue can not only save lives, but the extra time afforded before a condition worsens to the point where drastic treatment is needed, can also save the healthcare system time and money. Promoting healthy living and a personal responsibility for one's own health are concepts being embraced by healthcare professionals around the world. To achieve this dream, medical researchers recognise that people will need accurate and easy-to-use ways to monitor their own health. The ability to track whether healthy living initiatives are working

The prototype of the MIMOSYS: Mind Monitoring System app

and provide an early warning for worsening conditions is paramount to citizens wanting to take control of their health. Creating this healthier society will reduce burdens on healthcare systems and lead to a happier and healthier society in general.

One area in which these ideas are quickly becoming reality is in the realm of mental or cognitive diseases such as depression, addiction and dementia. These disorders are not only on the rise in many societies, but they are also difficult to diagnose. Often, a confirmed diagnosis only comes after a serious incident that has required hospitalisation. One big hurdle in diagnosing these types of conditions is self-reporting bias. People have a tendency to be unreliable when being questioned about their own emotional or mental health. It is a subconscious trait and most will tend to make themselves sound better off than they actually are. Unfortunately, questionnaires or interviews by health professionals are currently the only way to diagnose mental illness. A reliable biomarker has not been available until now. Researchers are now perfecting voice analysis technology that detects changes in vocal patterns, imperceptible to a human listener, signalling changes in stress levels and depressive symptoms.

RECOGNISING THE PROBLEM EXISTS
Voice activated technology has seen a big leap forward in recent years and this is one reason a vocal diagnostic biomarker is now possible. It also took the recognition of a problem and the desire for a solution. Dr Shinichi Tokuno, a Project Professor

with the Voice Analysis of Pathophysiology programme at the Medical School of the University of Tokyo, Japan, is one of the pioneers in this field of research. However, it was his experience working as a military medical doctor in the area of catastrophe medicine that allowed him to see the need for this work. 'When I was working as a military doctor, I faced the fact that many soldiers were stressed and so I began research in this field,' he says. 'After that, because of my experiences of the Great East Japan Earthquake, I felt strongly that the spread of this work to civilians was necessary, so I retired from the Army to devote myself full-time to this research.'

In situations of catastrophe it is impossible for specialists to conduct interviews, diagnose and treat all the affected individuals. However, similar conditions exist in society as well. In large corporations for example, it is extremely time consuming to identify and treat those who are feeling the effects of stress, anxiety or depression. The logistics are staggering and compounded by the aforementioned issues of reporting biases. 'Therefore, a screening technique which is inexpensive, simple and highly accurate is necessary,' says Tokuno. His solution relies on the fact that stress exerts an impact on human emotions. According to Tokuno: 'We developed a method to measure the mental health of a speaker based on the variations in emotional components extracted from the voice, rather than directly analysing stress conditions based on vocal data.'

HEALTHCARE IN A SMARTPHONE
Tokuno and his colleagues have shown that the technology works. Several studies

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have been conducted showing the accuracy and reliability of the method. 'The main advantages of the present technology are its ease of implementation and low cost,' says Tokuno. 'Its application in preventative medicine is therefore promising, and, if used in combination with the various biomarker-based diagnostic techniques currently in development, better induction to healthcare specialists will be possible.' The next steps will be fine-tuning the software and implementing it into a marketable package, such as a smartphone app.

The development of high-accuracy parameters for the software requires a great deal of speech data that is further linked to medical data, something no one institution could do on their own. Then there is the issue of language. 'For instance, it would be theoretically possible to use the present technology for languages other than Japanese, but no evidence currently exists, and verification for other languages cannot reasonably be done in Japan,' explains Tokuno. To address this, a joint research infrastructure using cloud technology to collect a variety of speech data is being built. Condensing the technology onto a smartphone is also in future plans. Tokuno and his colleagues envision an app called MIMOSYS: Mind Monitoring System, in which the users' vitality and mental activity are converted into a numerical value, which is displayed in a number of easy to read displays or charts. According to Tokuno, a large-scale demonstration experiment is underway using a prototype of this app. In the future, they believe MIMOSYS could be commonplace and used to diagnose many

conditions, including Parkinson's disease and dementia. Tokuna says that results for depression, dementia and Parkinson's have all been promising and a plan to expand the technology for schizophrenia, autism and suicide prevention is underway.

THE HEALTH FOCUSED HOME
Advances in technology and possibilities surrounding the Internet of Things are making our lives more convenient. For Tokuno, embracing this technology and lifestyle easily lends itself to healthcare. Everything from in-home sensors monitoring the inhabitant's environment and health, to medical tricorders and even smart toilets are being discussed by researchers and companies. In order to maintain the speed of innovation however, it will be crucial to develop strong collaborations.

In his own work, Tokuno recognised early on the need for strong partnerships and communication. 'In the beginning, when researchers in different fields talked, we recognised that it is important to have consistent definitions for words,' he says. 'For example, even the word stress is interpreted differently in medicine, psychology and engineering.' To fully integrate all the wonderful advances of health monitoring technology into a singular health focused home, researchers must work together. 'If researchers are not cooperative, sufficient materials and knowledge about different diseases in the fields of specialisation will not be assembled,' he says. 'Furthermore, without knowledge and skills in the field of engineering, this work cannot succeed.' ●