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'Seeing into the future: Personalized cancer screening with artificial intelligence ' 14th January 2022

HIGHLIGHTS

Scientists demonstrate that AI-risk models, paired with AI-designed screening policies, can offer significant and equitable improvements to cancer screening.

While mammograms are currently the gold standard in breast cancer screening, swirls of controversy exist regarding when and how often they should be administered. On the one hand, advocates argue for the ability to save lives: Women aged 60-69 who receive mammograms, for example, have a 33 percent lower risk of dying compared to those who don't get mammograms. Meanwhile, others argue about costly and potentially traumatic false positives: A meta-analysis of three randomized trials found a 19 percent over-diagnosis rate from mammography.

Even with some saved lives, and some overtreatment and over screening, current guidelines are still a catch-all: Women aged 45 to 54 should get mammograms every year. While personalized screening has long been thought of as the answer, tools that can leverage the troves of data to do this lag behind.

This led scientists from MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) and Jameel Clinic for Machine Learning and Health to ask: Can we use machine learning to provide

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personalized screening?

Out of this came Tempo, a technology for creating risk-based screening guidelines. Using an AI-based risk model that looks at who was screened and when they got diagnosed, Tempo will recommend a patient return for a mammogram at a specific time point in the future, like six months or three years. The same Tempo policy can be easily adapted to a wide range of possible screening preferences, which would let clinicians pick their desired early-detection-to-screening-cost trade-off, without training new policies.

The model was trained on a large screening mammography dataset from Massachusetts General Hospital (MGH), and was tested on held-out patients from MGH as well as external datasets from Emory, Karolinska Sweden, and Chang Gung Memorial hospitals. Using the team's previously developed risk-assessment algorithm Mirai, Tempo obtained better early detection than annual screening while requiring 25 percent fewer mammograms overall at Karolinska. At MGH, it recommended roughly a mammogram a year, and obtained a simulated early detection benefit of roughly four-and-a-half months better.

"By tailoring the screening to the patient's individual risk, we can improve patient outcomes, reduce overtreatment, and eliminate health disparities," says Adam Yala, a PhD student in electrical engineering and computer science, MIT CSAIL affiliate, and lead researcher on a paper describing Tempo published Jan. 13 in *Nature Medicine*. "Given the massive scale of breast cancer screening, with tens of millions of women getting mammograms every year, improvements to our guidelines are immensely important."

Early uses of AI in medicine stem back to the 1960s, where many refer to the Dendral experiments as kicking off the field. Researchers created a software system that was considered the first expert kind that automated the decision-making and problem-solving behavior of organic chemists.

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Sixty years later, deep medicine has greatly evolved drug diagnostics, predictive medicine, and patient care.

"Current guidelines divide the population into a few large groups, like younger or older than 55, and recommend the same screening frequency to all the members of a cohort. The development of AI-based risk models that operate over raw patient data give us an opportunity to transform screening, giving more frequent screens to those who need it and sparing the rest," says Yala. "A key aspect of these models is that their predictions can evolve over time as a patient's raw data changes, suggesting that screening policies need to be attuned to changes in risk and be optimized over long periods of patient data."

Tempo uses reinforcement learning, a machine learning method widely known for success in games like Chess and Go, to develop a "policy" that predicts a followup recommendation for each patient.

The training data here only had information about a patient's risk at the time points when their mammogram was taken (when they were 50, or 55, for example). The team needed the risk assessment at intermediate points, so they designed their algorithm to learn a patient's risk at unobserved time points from their observed screenings, which evolved as new mammograms of the patient became available.

The team first trained a neural network to predict future risk assessments given previous ones. This model then estimates patient risk at unobserved time points, and it enables simulation of the risk-based screening policies. Next, they trained that policy, (also a neural network), to maximize the reward (for example, the combination of early detection and screening cost) to the retrospective training set. Eventually, you'd get a recommendation for when to return for the next screen, ranging from six months to three years in the future, in multiples of six months — the standard is only one or two years.

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Let's say Patient A comes in for their first mammogram, and eventually gets diagnosed at Year Four. In Year Two, there's nothing, so they don't come back for another two years, but then at Year Four they get a diagnosis. Now there's been two years of gap between the last screen, where a tumor could have grown.

Using Tempo, at that first mammogram, Year Zero, the recommendation might have been to come back in two years. And then at Year Two, it might have seen that risk is high, and recommended that the patient come back in six months, and in the best case, it would be detectable. The model is dynamically changing the patient's screening frequency, based on how the risk profile is changing.

Tempo uses a simple metric for early detection, which assumes that cancer can be caught up to 18 months in advance. While Tempo outperformed current guidelines across different settings of this assumption (six months, 12 months), none of these assumptions are perfect, as the early detection potential of a tumor depends on that tumor's characteristics. The team suggested that follow-up work using tumor growth models could address this issue.

Also, the screening-cost metric, which counts the total screening volume recommended by Tempo, doesn't provide a full analysis of the entire future cost because it does not explicitly quantify false positive risks or additional screening harms.

There are many future directions that can further improve personalized screening algorithms. The team says one avenue would be to build on the metrics used to estimate early detection and screening costs from retrospective data, which would result in more refined guidelines. Tempo could also be adapted to include different types of screening recommendations, such as leveraging MRI or mammograms, and future work could separately model the costs and benefits of each. With better screening policies, recalculating the earliest and latest age that screening is still cost-effective for a patient might be feasible.

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"Our framework is flexible and can be readily utilized for other diseases, other forms of risk models, and other definitions of early detection benefit or screening cost. We expect the utility of Tempo to continue to improve as risk models and outcome metrics are further refined. We're excited to work with hospital partners to prospectively study this technology and help us further improve personalized cancer screening," says Yala.

Yala wrote the paper on Tempo alongside MIT PhD student Peter G. Mikhael, Fredrik Strand of Karolinska University Hospital, Gigin Lin of Chang Gung Memorial Hospital, Yung-Liang Wan of Chang Gung University, Siddharth Satuluru of Emory University, Thomas Kim of Georgia Tech, Hari Trivedi of Emory University, Imon Banerjee of the Mayo Clinic, Judy Gichoya of the Emory University School of Medicine, Kevin Hughes of MGH, Constance Lehman of MGH, and senior author and MIT Professor Regina Barzilay.

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‘Key IoT predictions in 2022 – The year enterprises take control’

28th January 2022

By Nick Earle , CEO at Eseye, an IoT solutions company that helps organisations improve their connectivity and more effectively utilise IoT.

While IoT has had several false starts over the last decade, the past 18 months has seen an acceleration in IoT adoption and deployments as organisations and industries have looked to remotely operate sensors and devices. This is partly in response to the pandemic but mainly as a result of IoT finally becoming mainstream as its value is recognised.

As we enter 2022, in today’s ‘always on’ world, this demand for remotely operated IoT devices is only set to continue to boom. This means businesses across all industries will need to adapt their operating models to meet the new and changing needs of both customers and employees. This trend is being pulled by a more remote and distributed user population and being pushed by a desire for enterprises to take greater control over their IoT deployments as new technologies allow them to do so.

To successfully take control, enterprises need strong and reliable cellular connectivity, and they also require visibility and security. This will enable organisations to accelerate the rollout of remote operating models that deliver exceptional, reliable customer and employee experiences at the network edge. Furthermore, there is a need for enterprises to manage their devices as they move between networks, whether they’re operated by different MNOs, or using their own private 5G network.

Looking ahead, we see the next year as one of real progress, provoking a major shift in the power dynamic between enterprises, MNOs, and IoT service providers. This will result in the biggest disruption to MNO business models to date as eSIMs solve the interoperability challenge, breaking the historical MNO lock-in and allowing enterprises to make their own decisions about IoT connectivity and network selection.

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Below, I’ve outlined my key predicted trends for 2022, and the resulting impact they will have:

1. The importance of Network Level Orchestration (NLO)

IoT devices that frequently switch operators are harder to track because they get a new

IP address each time they switch. Implementing enterprise-wide policies and security is difficult as a result. To overcome this, IoT vendors will need to use a single MNO-agnostic platform and require a single multiprotocol label switching (MPLS) network which will enable managed service delivery at the edge.

2. The MVNO market will fracture into three distinct groups

Future-conscious MVNOs will embrace disruption and pivot to become value players, supporting enterprises with key services as they take control of IoT deployments. They’ll offer localisation on multiple MNOs, provide a single MPLS network and manage customer switching, as well as offer hardware device design consultancy. A second group will undertake a race to the bottom on cost, supporting high volume, low data deployments. The remainder will be caught in limbo, unable to offer value or volume. These companies will experience shrinking opportunities, acquisition or in the worst case, business failure.

3. 5G networks in a box

The evolution of 5G will put the last piece of the puzzle under enterprise control. It will soon be possible to buy a private long-term evolution (LTE) network in a box, without needing an MNO. We will see Wi-Fi and Local Area Networks in buildings give way to 5G networks and a raft of new suppliers enter the market to meet the demand for private IoT.

‘Key IoT predictions in 2022 – The year enterprises take control’

In summary, 2022 will be the year several major elements of the traditional IoT technology stack change. Mass eUICC-compliant eSIM adoption will enable companies to build truly global product SKUs. The abstraction of the SM-SR switch from the MNO stack to the cloud will allow enterprises to set their own operator agnostic switching rules. The extension of encrypted network capabilities to the IoT edge will enable corporate IT departments to set security and compliance policy centrally and auto-deploy to the IoT edge.

The combination of these factors means enterprises can, for the first time, deploy operator agnostic IoT projects globally with the confidence that they are keeping control of security and policy.

This power shift will usher in the next phase of global digitisation, driving enormous opportunities for many of the IoT players, especially Systems Integrators. But it will have a disruptive impact on MNOs, who must adapt to a world where they are no longer in total control of the connection. To address this, the MNOs will increasingly white-label platforms that enable them to offer truly global connectivity via a ‘Star Alliance’ type interoperability model from MVNOs that offer Network Level Orchestration capabilities to the edge.

At the same time, 5G’s coming of age will drive considerable new IoT demand, especially from larger enterprises. This will, in turn, accelerate the adoption of these new technology capabilities. Without a doubt, 2022 will be a watershed year for IoT and one where enterprises finally take control.

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