A-Turf: Acoustic Encounter Detection for Privacy-Preserving Coronavirus Tracking

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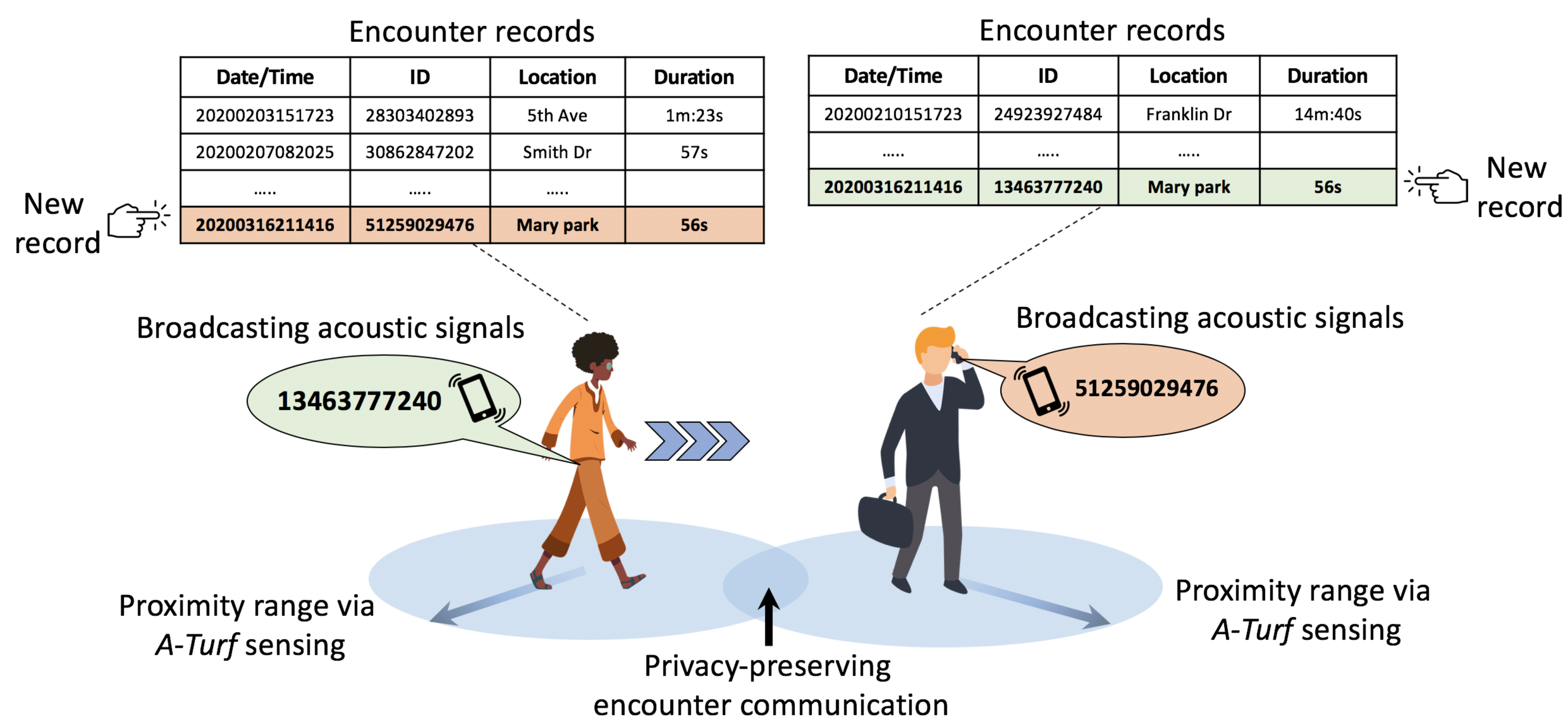
Background & Our System

The outbreak of the novel coronavirus (COVID-19) is unfolding as a major global health crisis whose influence extends to major aspects of our daily lives. Tracking and predicting how the virus could spread among people and regions have become critical parts of public health response strategies and early warning and prediction systems. To this end, we design a crowdsensing system called **A-Turf**, an acoustic encounter detection solution for privacy-preserving coronavirus tracking, by leveraging ubiquitous mobile devices. The system can accurately detect "encounters" between users within physical proximity, say the range of 6 feet (social distance), without the risk of disclosing private information such as unique mobile device MAC addresses. This work will overcome key challenges of infrastructure-based techniques (such as video monitoring systems) that are difficult to scale with broad coverage.

A Simplified Working Scenario

Bob has a mobile phone with A-Turf installed. His mobile phone broadcasts its randomly generated ID, using its speaker to send ultrasonic signals at a certain frequency f (or at multiple frequencies), either continuously or occasionally (at its discretion), to nearby phones. Note that the ID is randomly generated; it uses neither Wi-Fi nor Bluetooth MAC addresses. Meanwhile, Bob's phone also listens on frequency f, trying to receive ultrasonic signals from surrounding phones. Alice does the same. Once these two people are in the same physical proximity, Bob's phone can receive Alice's ultrasonic signals (i.e., Alice's randomly generated ID) and vice versa. Note that both Bob and Alice may receive multiple such ultrasonic signals from each other, depending on how long they are nearby. Once Bob's phone receives these signals, it will record them with the timestamp in its local database. Bob's phone can either automatically report these recordings to a central server (say at the CDC) or wait for Bob's manual processing. Alice's phone does the same.



Potential Real-world Working Scenario 1

- Periodically, the user generates a random ID and broadcasts it. An encountering user receives it and stores it in her own local database with a timestamp and location information on her mobile phone.
- If a user gets infected, the user uploads the list of random IDs she sent out to a public server (e.g., the CDC's server) at her discretion. Other non-infected users do not upload their encountering information to the public server.
- Other users can determine their individual risk levels based on publicly available data and their locally stored encounter information by matching their received random IDs, which represent encounters.

Potential Real-world Working Scenario 2

- Periodically, the user generates a random ID and broadcasts it. An encountering user receives it and stores it in her own local database with a timestamp and location information on her mobile phone.
- Each user volunteers to report all her sent and received random IDs with a location and a timestamp to the CDC. She can also report other information such as her personal ID, age and address. All such reporting decisions are made at her discretion.
- The CDC can proactively calculate the risk levels for individual users based on the reported encountering information and its collected infected data. It can then push such risk level information to them.

Novelty

To the best of our knowledge, A-Turf is the first work on encounter detection purely using acoustic signals in the context of virus tracking. The benefits of using acoustic signals rather than other signals (such as Bluetooth radio signals) are mainly due to the former's privacy-preserving nature —specifically, no unique MAC address disclosure and limited communication range—which is exactly what we need to avoid privacy concerns and "false encounters" between faraway users apart to avoid false alarms. The Bluetooth based solutions may use some mechanisms such as randomization to avoid unique MAC address disclosure. However, it is very difficult for them to limit the Bluetooth communication range within physical proximity, say the range of 6 feet.

Next Step

We are currently developing the A-Turf system. Our final deliverables will be (1) an interactive website showing a searchable map of virus spread and (2) a mobile app that can be downloaded to sense encounters and interact with the website for the encounter data as well as the infected information for risk level analysis. We are seeking collaborations in development and funding.