CATS: Crowd-based Alert and Tracing Services for the Post Pandemic Era

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***Abstract*—COVID-19 has been causing several pandemic waves worldwide due to its long incubation period and hostile asymptomatic transmission. Society should continue to practice social distancing and masking in public despite aggressive vaccinations until achieving population immunity. However, the existing technology solutions, such as contact tracing apps and social-distancing devices, have been faced with suspicion due to privacy and accuracy concerns and have not been widely adopted.**

This paper proposes a novel infection management system named Crowd-based Alert and Tracing Services (CATS) to build a safe community cluster. CATS applies social distancing and masking principles to small, focused communities to provide higher privacy protection, efficient penetration of technology, and greater accuracy. We have designed a smart tag for managing social distancing. We also implemented a Machine Learning (ML)-based face masking detection system for Modeling Safety Index in Crowd (Mosaic). Mosaic builds a new dense-mode crowd masking dataset to detect, count, and classify the crowd's masking condition and monitor social distancing.

I. Introduction

Fighting against the global pandemic caused by COVID-19, many countries make a mask-wearing and social distancing in public areas compulsory in parallel with aggressive testings and vaccinations to achieve herd immunity. Many scientists support that they are the most effective health measures to break the coronavirus transmission chain. However, the technologies ensuring those health measures have not been broadly adopted due to privacy and accuracy concerns. (e.g., Apple and Google's contract tracing API [1], PACT [2] [3], PrivateKit [4], etc.) Without gaining a critical mass of individual users, these personal technologies have been rendered useless. Although large-scale policy efforts have been made aggressively, the technologies cannot effectively support federal, state, and local governments' coordination and regulation enforcement logistics.

In this paper, we propose **Crowd-based Alert and Tracing Services (CATS) to build a safe community cluster,** which provides higher privacy protection, efficient penetration of technology, greater accuracy, and effective practical policy assistance. As illustrated in Figure 1, CATS enhances the technology-based tracing capacity by transforming the task from personal tracking to community gatekeeping and from binary to multi-context of contact information and policy assistance. First, as society gradually reopens, each community, such as schools, churches, businesses, and events, needs to be evaluated for appropriate gatekeeping methods such as masks and sanitization requirements, and temperature checks to ensure the members' safety. It is critical to deploy tracing and social distancing methods among the members. CATS facilitates tracing at a community or a facility level using multiple form-factors (i.e., a smartphone app, plug-in, or a smart tag) rather than an individual level to bear the characteristics of contacts according to the adoption choices of specific communities. Second, CATS enables public authorities to efficiently and dynamically assess their social distancing policies using the area-based safety value maps (opt-in data), various duration and distance alerts, and actively informing others via direct covert communication non-binary Safety Index Values (SI).

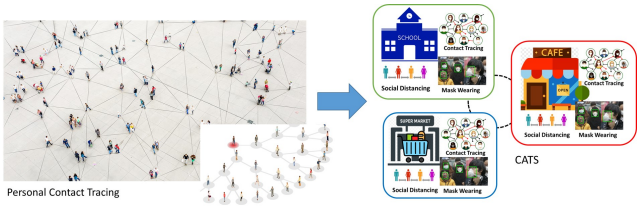

Fig. 1. CATS system concept vs. personal contact tracing

As of the first step, we have designed and developed a Machine Learning (ML)-based face masking detection system for **Mo**deling **Sa**fety **I**ndex in **C**rowd (Mosaic). As illustrated in Figure 2, Mosaic builds **a new dense mode crowd masking dataset** to detect, count, and classify the crowd's masking condition in addition to monitoring social distancing. It calculates spatio-temporal Safety Index (SI) values for each community instead of detecting individual mask-wearing conditions to ensure an individual's privacy. Mosaic calculates the weighted degree of each person's masking to obtain a more sophisticated SI model. The SI data can be shared or published to calculate the area-based SI maps (as opt-in data) for assisting effective policy decisions and relief plans against COVID-19. The evaluation results show that Mosaic detects various conditions and types of masking states and calculates SI values of a crowd effectively. Our goal is to investigate the impact and challenges of masking and social distancing the crowd to develop each community SI. While multiple face mask datasets have been constructed [5], [6], [7], [8], [9], none of them includes the scenarios of dense mode. To the best of our knowledge, this is the first work that effectively and scalably gauges the safety level from dense mode crowd image analyses for mask-wearing practices and social distancing in

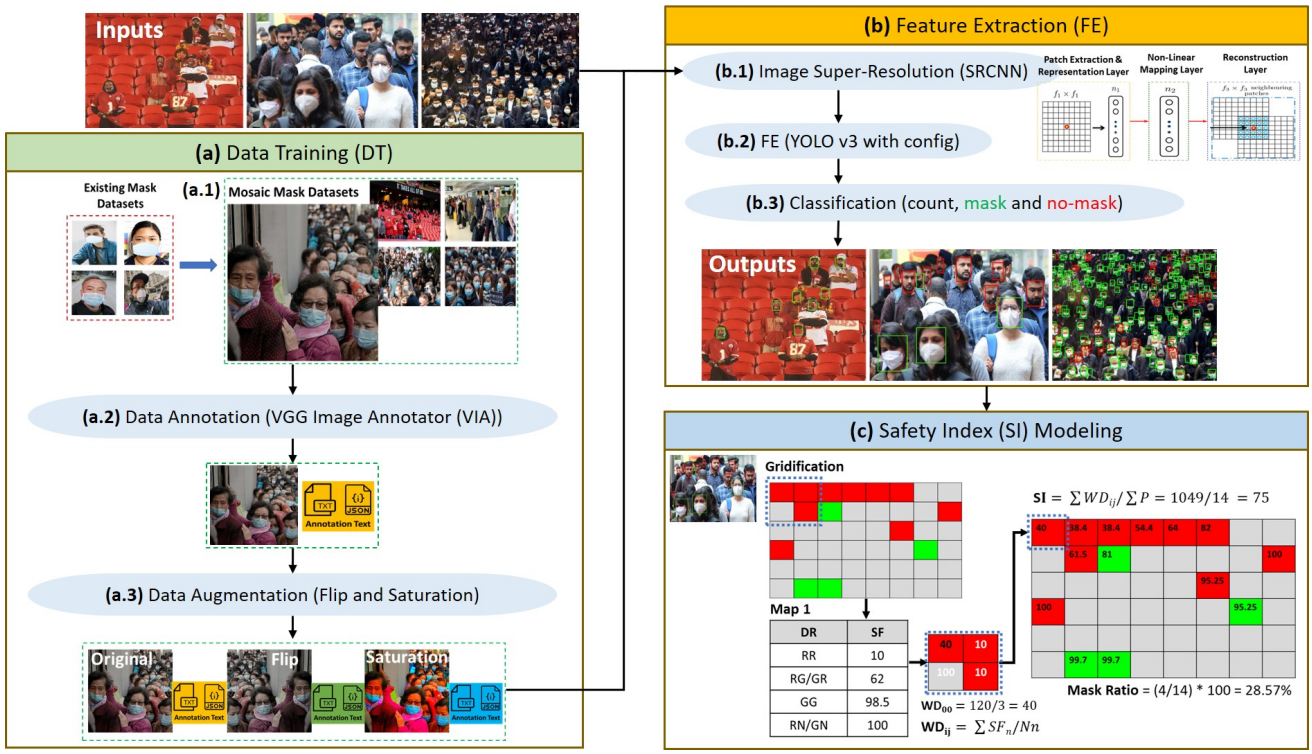

Fig. 2. Mosaic Architecture

a crowd.

II. Conclusions

We proposed Crowd-based Alert and Tracing Services (CATS), which is a novel tracing strategy and system to build a safe community cluster against COVID-19 and beyond using affordable Internet of Things (IoT) and edge-enabled Machine Learning (ML) technologies. We designed contract tracing, social distancing, and mask-wearing principles for small, focused communities to provide efficient penetration of technology, greater accuracy, effective practices, and privacy policy assistance. We have implemented a machine learning (ML)-based mask-wearing tracking method for building non-binary Safety Impact Values (SIV) and IoT-based social distancing and contact tracing methods. We have integrated CATS components into an edge-based IoT system. The experimental results show that CATS detects mask-wearing states and recognizes false-positive social distancing cases.

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