Final Proposal

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Introduction

Hand hygiene is an important part of public health, playing an essential role in preventing the transmission of disease. Despite its importance, compliance with guidelines established by organizations like the World Health Organization is suboptimal, especially in critical places like healthcare facilities. In the United States, poor hand hygiene practices have been linked to around 1.7 million infections annually, resulting in close to 100,000 deaths (Klevens et al., 2007).

The World Health (WHO) and the Center for Disease Control (CDC) stress the importance of hand hygiene in controlling the spread of disease (CDC, 2020). Ensuring adherence to established practices, however, is a persistent challenge. Current monitoring methods, such as manual observation and sensor-based tracking systems are limited in their effectiveness. Individuals tend to change their behavior when being observed (Srigley et al., 2014). Current sensor-based systems are plagued with accuracy and reliability issues. (Jiang et al. 2017)

To overcome these current challenges, AI could offer promising opportunities for the enhancement of hand hygiene compliance. AI technology has been used effectively in various fields, including healthcare, for object recognition and tracking activity (Jiang et al. 2017). Applying AI technology to hand hygiene monitoring has the potential to improve accuracy and efficiency in compliance tracking, reducing the need for human supervision, and leading to better public health overall.

However, the application of AI in hand hygiene monitoring is a relatively new area of research, presenting its own set of challenges and opportunities. These include technical challenges related to accurately capturing hand movements, ethical considerations related to privacy and consent, and practical issues related to the cost and ease of implementation (Dawson et al., 2021).

In our proposal we look at an innovative solution to the challenge of increasing hand-washing compliance: an AI-hand-washing coach. Building on our preliminary research on the topic, we will present an approach to improve hand hygiene through the use of machine learning AI algorithms and computer vision.

Proposed Approach

Given the significance of the hand hygiene challenge, our team considered a variety of potential interventions to improve compliance with handwashing guidelines.

Our options included educational initiatives such as hand hygiene seminars, visual reminders like hand hygiene promotion posters, installation of hand sanitizer stations, the use of hand wash dye to demonstrate the effectiveness of thorough handwashing, and the development of a hand cleaning machine. Despite having all these options, we were particularly interested in the potential of AI technology to transform hand hygiene compliance.

One such approach that we considered was conducting hand hygiene seminars. Traditionally, educational seminars have been used to emphasize the importance of hand hygiene and demonstrate the correct handwashing techniques (Gould et al., 2007). Although they are effective, these seminars can be time-consuming and may not be scalable to larger populations.

Another method we examined was the use of hand hygiene promotion posters. These visual aids which demonstrate the correct handwashing steps can be a simple and cost-effective method. The main drawback is that their effectiveness heavily relies on individuals' motivation and ability to interpret the information correctly (White et al., 2005).

We also contemplated developing hand cleaning machines and installing hand sanitizer stations. The former offers an automated and consistent hand cleaning process, while the latter provides convenience and accessibility (Picheansathian, 2015). However, both require significant resources for installation and maintenance, potentially limiting their wide-scale implementation.

After thorough discussion and based on our preliminary project conducted this semester with LayerJot, we chose to pursue an AI based hand washing coach as our primary intervention. We believe this approach offers significant potential for enhancing hand hygiene compliance due to its innovative use of technology, its potential for real-time feedback and correction, and its scalability and adaptability to various settings.

The AI hand washing coach approach leverages recent advancements in AI technology for object recognition and activity tracking (Jiang et al., 2017). As opposed to manual and sensor-based methods of hand hygiene monitoring, AI-based systems can provide real-time, non-intrusive monitoring and instantaneous feedback, which can significantly enhance hand hygiene practices (Edmonds et al., 2019).

We are particularly attracted to the AI hand washing coach approach due to its potential for broad applicability. While the other interventions that we came up with such as hand cleaning machines might be effective, their applicability may be limited by factors such as cost, space, and installation requirements. On the other hand, the AI hand washing coach, being primarily software-based, can be implemented in various settings, including hospitals, schools, public restrooms, and even homes.

Proposed Methods

To ensure hand hygiene compliance with the World Health Organisation's hand-washing guidelines, we propose the following approach:

The first step involves designing a device with a downward-facing camera trained on the sink. The camera will capture real-time video footage of users washing their hands for our device to analyze. We will ensure the camera is positioned optimally to have a clear view of hand-washing while respecting user privacy. The device will have an integrated computer to analyze the footage.

The video feed captured by the device will then be fed to an Ai hand-tracking system called Media Pipe. The system uses machine learning algorithms to identify and label 20 3D coordinate points on each hand to ascertain the exact position of both hands. The AI can cope with fingers occluding one another to an acceptable degree, so it can keep up with the odd hand positions one must make to fulfill the World Health Organization's hand-washing steps. The hand-tracking AI has already been trained and is freely available so we do not have to worry about training it ourselves.

The labeled points must then be fed into a second AI system that we must train on correct and incorrect footage of hand washing in various settings and angles. The second AI will be responsible for analyzing the position and movement of the hands to ensure compliance with the World Health Organization's hand-washing steps. The AI will recognize the different stages of hand washing per the World Health Organization's guidelines and provide real-time feedback on the user's compliance by prompting the user on a small screen.

If the user is found to be out of compliance, the second AI will select a prompt from a premade library of visuals to provide corrective feedback. The prompts will relate to both the timing and the form of the user's hand washing. The device not only allows employers to monitor their employees' hand-washing practices, but it also allows for real-time feedback to actively people at all equipped sinks to improve their handwashing practices via concise corrective visuals.

The ultimate goal is to create an AI handwashing coach that can effectively monitor compliance with World Health Organization guidelines, provide real-time feedback, and help users improve their handwashing practices at an accessible cost. Our goal is for the device to be accessible to medical institutions, schools, and food preparation facilities alike. We will accomplish this using 3D printing in conjunction with cost-effective computing solutions like raspberry pi's to create an affordable product. 3D printing also gives the advantage of easy customizability, which we can facilitate by providing free schematics and cad files.

Expected Outcomes

With the implementation of our AI handwashing coach, we can be certain that there will be numerous beneficial outcomes, such as improved handwashing compliance and public health.

We expect that there will be an increase in handwashing compliance in various settings, such as hospitals, schools, and public restrooms. As the AI handwashing coach provides real-time feedback and corrections, it will encourage users to adhere to the proper handwashing techniques recommended by health organizations. This expected outcome is based on past studies that suggested real-time feedback can significantly enhance compliance with hand hygiene guidelines (Srigley et al., 2014).

We also see a considerable reduction in the spread of infectious diseases and related public health issues. Hand hygiene is a primary preventive measure against many diseases, including those caused by bacteria, viruses, and other pathogens. By improving hand hygiene practices, the AI system can help prevent the transmission of these pathogens, potentially leading to fewer outbreaks and a lower burden on healthcare systems. (Allegranzi & Pittet, 2009).

The system will generate valuable data regarding handwashing practices, which can then be utilized to inform future interventions and policies. Data on compliance rates, handwashing duration, and techniques used can be analyzed to find trends, improvement areas, and the system's effectiveness. This type of data-driven approach can significantly enhance the efficacy of public health efforts aimed at promoting hand hygiene. (Lydon et al., 2017).

The AI handwashing coach is promising for enchanting hand hygiene compliance, reducing the spread of infectious diseases, and informing data-driven hand hygiene policies and interventions. These outcomes will overall benefit public health efforts significantly and contribute to solving our grand challenge.

Broader Impacts

The impacts of our AI handwashing coach are not limited to improving hand hygiene compliance and reducing the spread of infection. We believe that the technology we are developing will have broader implications, especially when considering aspects of public health and equitable worldwide impact.

The use of AI in public health, specifically our goal of improving hand hygiene, is a novel approach that has vast potential for success across various sectors. While similar technologies have primarily been reserved for healthcare facilities, the AI handwashing coach can be implemented in a variety of settings, including agriculture and the food processing industry. A broader application of this AI technology could lead to safer working conditions, a cleaner environment, and enhanced public health outcomes (Jiang et al., 2017).

The AI handwashing coach has the potential to make a considerable impact on the reduction of healthcare-associated infections (HAIs). Poor hand hygiene is a leading cause of HAIs, which account for an estimated 1.7 million infections and 100,000 deaths in US hospitals alone (Klevens et al., 2007). By improving hand hygiene compliance, our AI technology can help significantly reduce these numbers.

In terms of social equity, the AI handwashing coach can play a vital role in low-income and developing regions. If made cost-effective, this technology can be implemented in areas where hand hygiene education and compliance are often overlooked due to more pressing economic and social challenges. This would help reduce health disparities and improve public health outcomes in these regions (Peiffer-Smadja et al., 2020).

Finally, our approach is designed to be inclusive and accessible. By providing real-time, personalized feedback, the AI handwashing coach can accommodate different learning styles and ensure that all users, regardless of their prior knowledge or abilities, can improve their hand hygiene practices.

In conclusion, the broader impacts of our AI handwashing coach extend beyond improved hand hygiene and public health outcomes. It represents a novel application of AI technology with significant potential for enhancing social equity and inclusion.

Visual

https://www.adventhealth.com/blog/it-safe-use-public-bathrooms

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