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Project Summary:

Modern systems that require user authentication always have a weak point of failure; that being the user. Consider, from an individual's perspective towards accessing a variety of accounts whether at work or at home. They are either filled with passwords, PINS, and some combinations with user identification. This causes the inconvenience of having to remember passwords and identification. Different services having different criteria for their methods of authentication don't help solve the issue of security that becomes inconvenient.

What we propose is a novel biometric authentication system leveraging electromyographic (EMG) signals. These signals, created my muscle activation, will be ideally used in the effort of uniquely identifying individuals. Similar to how a fingerprint scans someone's finger, analyzing EMG signals will allow us to create a signature tied to an individual. There may be several more aspects to the use of these types of signals, including mood analytics, and health study merits.

The project will involve the use of commodity EMG signals made available by Thalmic Labs and their Myo device. The study will involve the use of several other sensors to analyze their comparative effectiveness, however, the use of relatively cheap equipment will be preferred for the purposes of this study.

In particular, the design of the EMG sensor involved in the study will leverage the movement and replicability of that movement of a particular limb. Our preliminary work has involved analyzing the replicability of motions influenced by muscle memory. Muscle memory, which may be practiced every day, has the impression of being reliably replicable and distinguishable from adversaries trying to emulate a motion.

Intellectual Merit:

This proposed project will have a variety of merits which will span from a usability security standpoint, and towards health and affirmative computing applications. Firstly, the novel approach to using analytical methods on muscle memory for user authentication. This study will allow for a more accurate measure to be created to quantify the effects of muscle memory. The study will investigate how similarly difference individuals. With the results from this study, it is foreseeable that applications to injury detection or physical therapy could be built through further study regarding changes in muscle memory.

From a usability standpoint, this project will cover a new perspective on the lines of pervasive computing in mobile devices. Mobile devices allow for identity to be carried in some digital form everywhere, made even easier by the ubiquity of fingerprint readers on mobile devices. Our work will explore the application of a 'continuous authentication' model where the user can have their identity consistently monitored via EMG signals, giving attackers a more restrictive window on identity theft.

Concerning knowledge towards health applications, there is a lot of information that may be gained. With the study, we will gain a better understand of muscle memory and be able to quantify its effects. Results from the analysis will allow for an expanded space to research muscle-based studies. The introduction of a measurement of changes in muscle memory or degrees of memorization may be useful in sports applications where athletes may be analyzed for quantifiable changes in performance either due to injury, or even emotions/moods.

Broader Impact:

Through successful completion of the project, we will have a system that allows individuals to be authenticated without any extra effort to memorize or learn new methods for authentication. Muscle memory which has presumably already been practiced will be a familiar motion. Applications for the work will include mobile authentication, or authentication for warehousing or office facilities where doors or gates are usually authentication points. With the application of our work, any unusual EMG signals caught (or lack thereof) will be caught.

There will no longer be passwords that need to be remembered, and attackers will not have avenues for calculating EMG values, due to their very subtle and erratic nature. This will be different from fingerprinting which can be manufactured from residual fingerprint marks.

Project Description:

A1. Recording Muscle Memory on Password Entry (Preliminary)

Preliminary work has already been conducting concerning the reliability of using muscle memory for authentication when analyzing measurements of EMG signals recorded form users typing in well-known passwords. The purpose of this was to reinforce security off passwords as a form of dual step authentication. Users were tested on their ability to recreate password typing motions, with/without keyboards, while under the effects of muscle fatigue, and under different stress levels where speed/accuracy were weighed varyingly.

There are a few tests that need to take place in order to make clear that EMG signals are unique and replicable. In addition to testing muscle memory, it was beneficial to explore the space of nearly learned muscle movements and to see whether or not users could consistently replicate motions not engrained in muscle memory (such as typing an unfamiliar phrase, or someone else's password)

The main purpose of this investigation is to learn whether or not muscle memory can be accurately replicated, and that this replication can be distinguished from other muscle movements, and those muscle movements from other individuals; be hostile, or benign.

A2. Recording Muscle Memory on Basic Movements

The next step is to analyze muscle memory which takes place in a less controlled fashion. These tests may include simple motions, such as twisting a door handle, or walking. The next step that follows these simple motions would be to venture into training muscle memory to capture the rate at which muscle memory is built and how effective the system would be to adjusting to user circumstances, while still failing closed, rather than failing open.

The tests under this investigation would follow the same logic as in A1 where they are tested under difference circumstances of fatigue, and emotional levels.

B. Quantifying Consistency of User Authentication Attempts

Once all our data has been compiled and cleaned, analytics driven experiments on our EMG collection can begin. A variety of metrics may be used to calculate accuracy of user authentication attempts, varying from the application of machine learning technique, to simple signature calculation and comparison. Our study will include a variety of these analyses to determine the most effective method of verification.

Preliminary work lead to heavy use of image processing techniques due to the similarity of the EMG signals to edge and face detection, however applied to a 1 dimensional data set, rather than 2 dimensional. Calculations will involve creating a metric that computes a signature to which we will compare future authentication attempts to the user. Differences between our database entry and future entries can be a primary metric for determining the consistency of muscle memory. With a rolling average of EMG values over intervals of interest, we will be able to quantify the variance of each attempt.

D. Brute Force Attempts to Test False Positive Rate

A very important aspect of our investigation lies in making sure that our system has a low false positive rate, as we would prefer our system to fail closed, rather than fail open in most situations, leading to a safer route of supplying a 2^{nd} step verification, such as a finger print.

Through these brute force attempts, we will have test subjects copy gestures in attempt to gain access to the system with a false positive authentication.

Evaluation:

Our work will be evaluated based off its merits of a security authentication system as a whole. Primary metrics involved in this evaluation include false positive rate, and some qualitative attributes such as convenience. Our system will be marked as a success if the results from user feedback show that the system provided at least as much security as a password entry, but with much more convenience.