Regulating Access in Office Environments with Digital Pens

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CHI'20,, April 25–30, 2020, Honolulu, HI, USA
ACM 978-1-4503-6819-3/20/04.
https://doi.org/10.1145/3334480.XXXXXXX

Abstract
Digital pens are capable of recognizing handwritten characters or words using various sensors. Since handwriting is very unique, individuals can be identified by written characters or signatures. However, current sensor technology is not yet able to provide error-free identification. Nevertheless, the use of handwriting for authentication can be advantageous in certain environments. This paper discusses office environment as possible use case and points out the challenges of different sensors that could be possibly integrated into digital pens.

Author Keywords
Digital pen; handwriting recognition; authentication

CCS Concepts
•Human-centered computing → Ubiquitous and mobile computing systems and tools; Pointing devices;

Introduction
Digital pens can be used to digitize inputs such as drawings or handwriting. To reconstruct single strokes or even signatures, two methods can be applied. First to detect the position or ink of the pen on a sheet of paper and second to reconstruct individual characters on the basis of the written trajectories. However, especially the latter is challenging since handwriting is very individual. This makes digital pens

obviously applicable for authentication purposes. The similarity to signing a contract makes it also very intuitive in this field of application.

However, one can ask why are digital pens not commonly used i.e. for contracts or payments today as handwriting is well researched in forensics [8]? In the same way, the question may be raised whether the technology of digital pens is at all capable of extracting a sufficient amount of individual features. This paper discusses the challenges and limitations of different sensors that have been integrated into digital pens for authentication. Additionally it is shown why and how digital pens should be applied for user identification in office environments.

Related Work & Handwriting Sensors

Handwriting as an input mortality has been investigated for over five decades [12, 15]. Some of the previous approaches applied visual features, e.g. from cameras, for recognizing single characters or digits [2, 5, 11, 16, 17, 18]. There are also products on the marked that use cameras for detecting dot matrices on paper in order to recognize the position of strokes [1]. Alternatively, others use ultrasound and infrared light for position estimation [6].

On the other hand, non-visual features offer the advantage that no actual representation of the handwriting must be stored. For instance pen motions achieve high recognition rates [7, 22]. In combination with pressure sensors characteristics can be collected to identify individuals [4, 9].

Another source for handwriting measurements is audio. When the pen tip touches a surface, envelopes of sound or sprectral features can be used to distinguish small sets of words or characters [13, 14, 20].

Also of interest is the combination of motion and audio measurements which has been explored by Schrapel et al. [19]. In contrast to force measurements, sound is more robust to obsolescence but error-prone to environmental noise.

In addition, fingerprint sensors have been integrated into pens for authentication purposes [21]. Furthermore, magnets have been used to extend the interaction area of mobile devices [10] with stylus pens.

Example Environment

Many use cases could be chosen for digital pens. One representative example are office environments with workshops and tools such as laser cutters are usually subject to compulsory instruction or instructions must be confirmed in writing. Without a briefing, there is no insurance cover for use in addition to health risks. For this reason, tools are locked in workshops or are only accessible with a tansponder or code. Companies use RFID transponders or keys that can be lost or passed on. Passwords or numerical codes can also be shared or even observed by unauthorized individuals. Biometric features such as fingerprints, iris colors or handwriting make it necessary for authorized personnel to unlock devices. The first two mentioned biometric methods are usually not applicable due to privacy reasons.

Environmental Requirements

In office environments it is required that access to different systems can be dynamically controlled. This includes temporarily access to equipment such as coffee machines or computers for users. On the contrary, devices that are subject to instruction should only be operated by authorized personnel. The digital pens can be provided to the employees as personal pens or placed next to the locked tools. It should not be possible to falsify access without a certain

effort.

Biometric Sensors

In the related work section, many sensor systems have already been mentioned that can contribute to the recording of biometric features. All are subject to certain challenges, which are described in the following.

The use of a camera integrated in the pen does not achieve sufficient safety requirements. Signatures could be filmed and used by other people for authentication purposes.

Measuring how many times and for how long a pen tip touches the paper is not sufficient for authentication. However, such characteristics are also used in addition to other sensors [19].

The use of motion data in digital pens is subject to various limitations which are mainly related to the manner in which the pen is held. There could also be an influence whether a person is standing or sitting during writing. To mitigate this limitation, pens should restrict the way a pen can be held. This could be done by attaching a handle to the pin. Additionally, the recognition should rely on a few sample hand writings in a sitting and standing position.

Sound, as mentioned before, is error-phone in noisy environments. Therefore, noise cancelling and/or shielding of the microphone inside the digital pen could be a mitigating factor. It is necessary to test whether the sensor can be applied in noisy environments. Otherwise, the recognition sould only rely on other measurements.

Integrating pressure in digital pens is very challenging because stress affects how much a user presses the pen onto the paper [3]. This results in a strong influence on the measurements that may lead to rejection of users.

Additional tracking of the digital pen by magnets could provide features related to the visual representation of the signature. In this case, a magnetometer would have to be integrated into the pen, which detects an external magnet that is located near the intended interaction area e.g. a sheet of paper for the authentication process.

Conclusion & Future Research

Based on the previous described sensor technology, which can currently be found in digital pens, it can be assumed that high-precise user identification is hardly possible. Human related influences such as stress [3] can result in different handwriting styles. Technical measurement deviations cause errors in the recognition. Therefore, nowadays systems based on digital pens can not be applied for higher security levels. On the other hand, where less stringent security requirements can be imposed, as in some office environments, digital pens may be a feasible alternative.

In the future it should be investigated which additional biometric features can be measured. For example, the chemical composition of sweat would be a possible identification criterion. The sensor should be attached to the outer side of the housing to measure sweating of the hands. Also skin thickness or the finger size could be measured. As a limitation, gloves cannot be worn, which makes those features inappropriate for use in clean room environments.

In general, the discussed sensors should be integrated and tested together in a future prototype. To this end, it would also be necessary to investigate how the signature and the measured sensor values change under different influences on the user. Based on the results, the robustness of handwriting authentication must be examined to regulate access in office environments with digital pens.

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