# Using Knock as Input Method for Designing the Home Security System

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## Abstract

Home security is one of the most critical concerns in daily life. In this paper a novel human–machine interface was integrated in a home-security system. The developed system applies the action of knocking as the input interface to unlock a door without using keys. First, the unlock areas on the door are set. When a user knocks on the door, the system obtains knocking information from six vibration sensors in the door. A pattern-recognition algorithm subsequently identifies the knocking pattern of the user, including the knocking areas and the knocking sequence. According to the simulation results, the accuracy of identifying the correct knocking areas was between 90% and 93%.

Keywords: home security system, human–computer interface, knock, lock, pattern recognition

## 1. Introduction

In recent years, numerous studies have investigated human–computer interactions [1]-[5]. This research field is based on the design of systems that allow for a more intuitive communication between users and machines or computers. Because the actions (e.g., touching, clicking, and tapping) generate vibration signals, some researchers have designed novel human–computer interactions by analyzing seismic-vibration information. For example, Yonezawa et al. used vibration sensors to design switches [1]. Harrison et al. analyzed the vibrations of finger tapping by using pattern-recognition algorithms; they applied this mechanism in the control of a music player, the answering of phone calls, web browsing, and photo editing [2]. Poletkin et al. [3] analyzed vibration information to identify the tapping locations of users.

Home security is a critical concern for most people in daily life. Traditional home security relies on locks but it is generally inconvenient to carry numerous keys. In this study, seismic-vibration information was analyzed to develop a home-security system. Initially, users defined their personal unlock locations on the door and the corresponding knocking sequence. When they knocked on the door to unlock it, the home-security system detected and analyzed the vibration signals, and the pattern-recognition algorithm identified the knocking locations. If the knocking locations and sequence were consistent with the predefined unlock pattern, the door opened.

## 2. Implementation

The home-security system comprises a setting stage and a usage stage. In the setting stage, the user defines several unlock areas on the door (knocking locations) and thereby constructs the recognition classifiers to identify the knocking locations (defining the personal unlock pattern). In the usage stage, the user is asked to knock on the unlock areas in sequence.

### 2.1 Setting Stage

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The setting stage comprises three steps.

**Step 1**: Defining the unlock areas

In the first step, the user defines the unlock areas on the door. The unlock areas represent one element of the password needed for unlocking the door. After defining the unlock areas, the user defines the order of knocking on the unlock areas. The knocking order is the second element of the password.

**Step 2**: Collecting knocking information

The home-security system comprises six vibration sensors that are installed on the door (Fig. 1). If the user knocks on the door, the vibration sensors detect the vibration signal. The various distances to the sensors from any given knocking location result in distinct arrival times of the knocking signal. As the example in Fig. 1 shows, Sensor 4 detects the shortest arrival time, because the knocking location is closest to it.

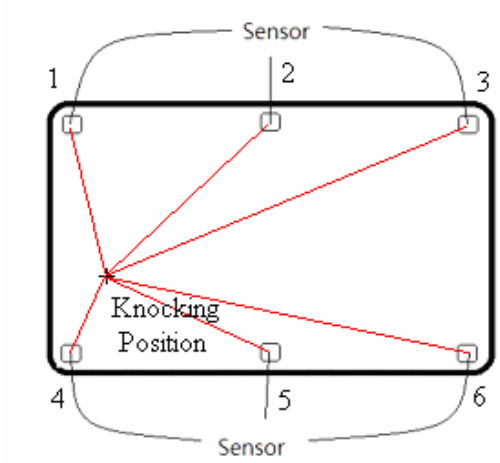


Fig. 1. Six vibration sensors are installed on the door

**Step 3**: Construct recognition classifiers

The home-security system uses a pattern-recognition algorithm to identify the knocking locations. In this study, the *k*-nearest neighbor (*k*NN) algorithm [6] was employed to construct the identification classifiers. To train classifiers with the *k*NN algorithm, the user knocks 10 times on each unlock area to generate the training patterns.

### 2.2 Usage Stage

In the usage stage, the user knocks on the chosen unlock areas in sequence. If the user knocks on the correct areas in the correct sequence, the home-security system unlocks the door. Fig. 2 shows a flowchart of the unlocking procedure.

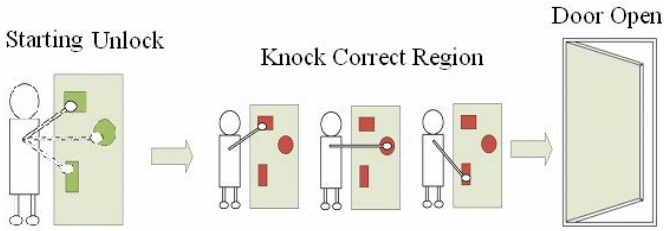


Fig. 2. Flowchart of unlocking the door

## 3. Experiments

In the experiments, a data set was used to test the rate of accuracy of the proposed method. As shown in Fig. 3, the data set comprises nine unlock areas. For each unlock area, 60 knocking patterns are generated by 10 users. In the data set, the numbers of the training and testing data are 450 and 90, respectively. In the experiments, the *k*NN algorithm was used to identify the knocking areas, and the value of *k* was set to 5 for the *k*NN algorithm. The experimental result is listed in Table 1. The accuracy rates for identifying the correct knocking area was 90%. The experimental result showed that the performance of the proposed method was satisfactory. Therefore, using knocking as a password mechanism for the lock of a door is viable for a home-security system.

Table 1. The experimental results of Dataset1 and Dataset2.

| | Number of Class | Number of Training Data | Number of Testing Data | Accuracy Rate |
|---|---|---|---|---|
| Dataset | 9 | 450 | 90 | 90% |

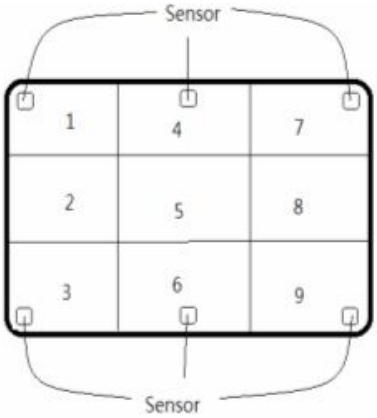


Fig. 3.The unlock areas of dataset.

## 4. Conclusions

In this study, a new human–machine intertraction was integrated into a home-security system. The system used vibration sensors and an Arduino microcontroller to measure the vibration signals of knocking on a door. The vibrational information was then identified by applying a pattern-recognition algorithm to locate the knocking areas and the knocking sequence. Thus, the users could unlock the door with a unique knocking pattern.

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