Design Secured Smart Door Lock Based on Jaro Winkler Algorithm

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Abstract

The security nowadays considered as significant topic specifically in design smart home. This paper is dedicated on an authentication problem in design smart door lock authentication using string matching technique based on password string.

This work contains two main parts, Android application (remote control) and control circuit using Arduino UNO, plus the communication medium based on Bluetooth technology which is used to send and receive information and commands in this work.

The main purpose of design smart door lock, using Jaro Winkler algorithm is to compare the registered password security with each entered password which may contain some wrong or swapped characters. The results show more strength authentication for access in real-time.

Keywords: Jaro Winkler, authentication, Arduino UNO, Android

1. Introduction

The modern design of smart homes has attentive on smart controls and convert conservative switches to compact control system[1]. The smart home technologies have focused on networking (wiring and wireless systems), controlling (remote control, smart phones, and web browsers), and smart devices (green, energy consumption, security, environment, and entertainment)[2,3,4,5]. An illustration of smart home technologies is shown in figure (1).
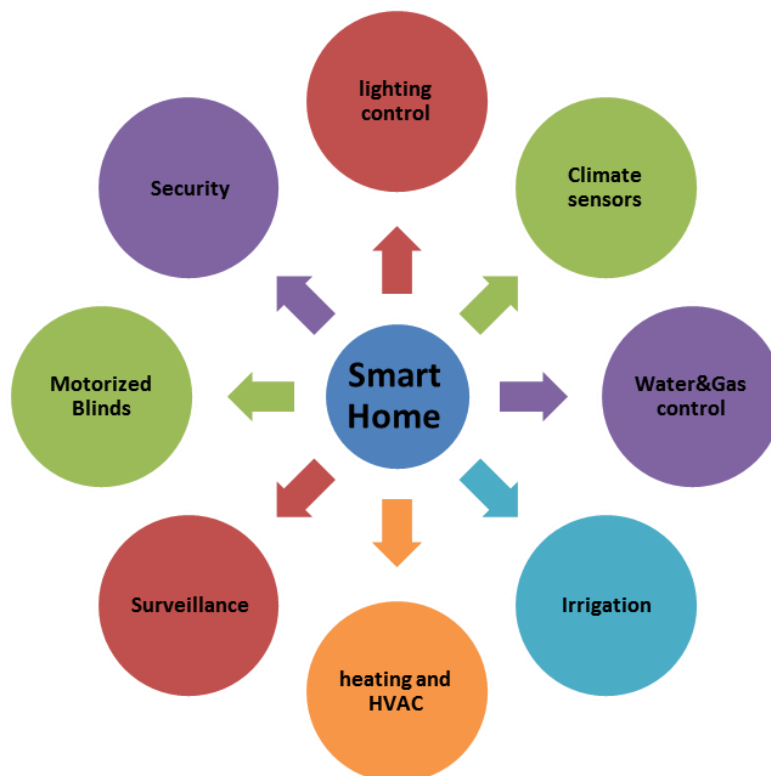

Figure (1) Category of Smart Home Services

The remote controllers in smart homes have been used in numerous services such as home appliances control;decrease power consumption, communication and security. This work focuses on implementation of the security issue in smart door lock [2].

Smart door lock is considered as a smart authentication access control based on authenticated person to lock/unlock the door in smart home. One of the most advantage of design smart door lock is to control door open/close by an authentication person, other advantage is can be accessed using smart phone where the use normal key may be lost or stolen [6].

There are several experiments and approaches about security issues in smart door lock, one of these techniques is using GSM (Global System for digital mobile telecommunication) technology to send SMS (short message service) to door controller and receive message to the holder; GSM not secured enough and

can operate the controller by other users [7], another technique is using the Bluetooth to lock/unlock door by send usual commands [8], other technique based on motion sensor PIR (Passive Infrared Sensor) for locking/unlocking the door; this method has using authentication procedure [9], and the last technique based on RFID (Radio Frequency Identification) as accessed, RFID can be destruction when faced to magnetic field [10].

In this paper, the password send to controller attached to door lock actuator which collects the information of authenticated user's smart phone and password compared by Jaro Winkler algorithm. The connected between smart phone and door controller based on Bluetooth technology.

2. Jaro Winkler Algorithm

This algorithm has been applied in this work as a one of the methods that is used for a string comparison because it is most efficient and accurate in similarity metrics [11]. The Jaro Winkler algorithm has been used for matching two strings which contain spelling mistakes and find approximation of common matched characters. The result value of this algorithm is always returned between 0 and 1, the strings are identical when the result value is 1 only. The definition of Jaro is explained in equation (1) [12].

$$J(s,t) = \frac{1}{3} \times \left(\frac{com(s,t)}{s} + \frac{com(t,s)}{t} + \frac{com(s,t) - transp(s,t)}{com(s,t)} \right) \dots (1)$$

Where s and t are the strings need to compare. And Jaro Winkler string comparator is calculated in equation (2).

$$W(a,b) = J(a,b) + P * N * \left(1 - J(a,b)\right) \dots (2)$$

Where a and b are the string need to be compared, P is Winkler constant (P<0.25), and N is the number of character similarity [13]. An example of comparison two strings using Jaro Winkler algorithm has been explained below in details.

To compare two strings s=MARTHA, and t=MARHTA, by applying equation (1) to find Jaro value:

M=6, is number of matching characters
SL=6, is the length of first string (s)
TL=6, is the length of second string (t)
MS=1, is the mismatch characters (2/2=1)

$$J = \frac{1}{3}\left(\frac{M}{SL} + \frac{M}{TL} + \frac{M-MS}{M}\right)$$
$$J = \frac{1}{3}\left(\frac{6}{6} + \frac{6}{6} + \frac{6-1}{6}\right) = 0.944$$

Now, applying equation (2) to find the Jaro Winkler value as below:

P= 0.1, Jaro Winkler constant
MT=3, number of prefix match

$$W = J + (P * MT * (1 - J))$$
$$W = 0.944 + \left(0.1 * 3 * (1 - 0.944)\right) = 0.961$$

In our work, these steps of algorithm has been applied in Arduino language platform based on Java to compare both registered password with password sent from smart phone device via Bluetooth where try to lock/unlock door actuator. In addition to that, a threshold value has been set for authentication access where score of W should not be less than 0.9.

3. Proposed Work

The proposed work has focused on design hardware for smart door lock using Bluetooth technology and Android OS (Operating System), besides the implementation of Jaro Winkler algorithm for authentication access. The phases of proposed design have been illustrated in figure (2).

Figure (2) Proposal Work Phases

In this work, an application is designed using smart-phone with Android platform as remote control. The Android platform has including Bluetooth APIs (application program interfaces) which provides to access to the Bluetooth functionalities. To create connection between remote control and electronic controller circuit for door lock, need to initialize the server and client socket on same channel. Then, the server side is listening to the request of client side, and the last one waiting for permission from server for accepting pair. The remote control application design is shown in figure (3).
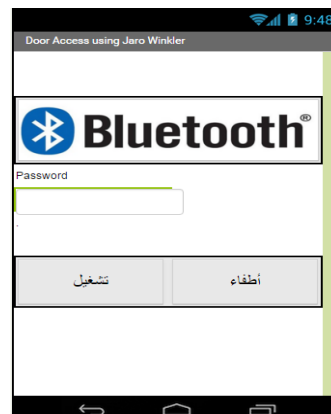

Figure (3) Remote Control Application Designed in Android Platform

The Bluetooth command in remote control application used to display list of Bluetooth devices

within the range of detection. The procedure of Bluetooth API is shown in figure (4).

Figure (4) Bluetooth Pairing Step in Client Side

After the pairing step has done, the client has collecting the information of the device and select device ID. In the proposed work, device ID has considered as the plain stream because it is unique information and phone number is considered as the key-stream. The flow code of retrieving device information is shown in figure (5).


Figure (5) Procedure Send Password for both Commands (lock and unlock)

As shown in figure (3) there are two commands (On/Off) used to control door lock. Within each of these commands, password string has been send via Bluetooth to the circuit control. There has been used a

Bluetooth module (HC-06) connected to Arduino UNO which doing pairing and receive data from smart phone, after that, the Jaro Winkler algorithm has been applied in ATMEGA328 controller to find the matching score between password strings. During experience work, the proposed work is evaluated with proposed algorithm by using different password strings as described in table (1).

Table (1) Jaro Winkler Comparison Different Password Strings

Password String (1)	Password String (2)	Jaro Winkler	Authentication state
Ahmed123	Ahmde123	0.98	True
Ahmed123	Ahmdd132	0.91	True
Ahmed123	Ahdme12	0.93	True
Ahmed123	Aahdmed123	0.90	True
Ahmed123	Aahed133	0.85	False
Ahmed123	Qhmed123	0.92	True

The whole hardware elements in the proposed design are illustrated as schematic circuit and real design in figure (6).
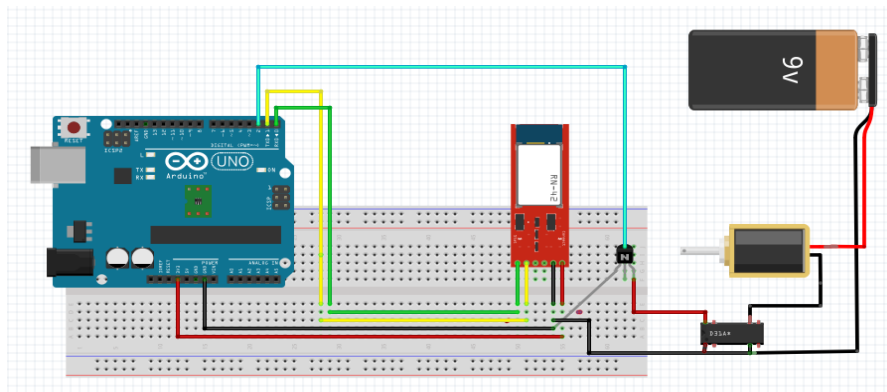
(a)
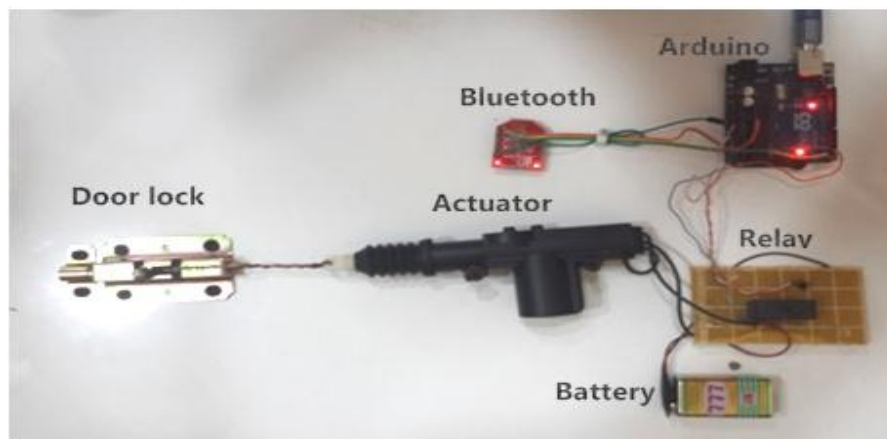
(b)

Figure (6) Proposed Hardware Design (a) Schematic Circuit, (b) Real Design

The Arduino UNO contains a microcontroller (ATMEGA328) which has USB (Universal Serial Bus) connection, PWM (Pulse Width Modulation), analogue, and digital feature. In the proposal work, Bluetooth module (HC-06) is connected to serial pins with microcontroller (TX and RX) and power with 3.3v as shown in figure (7).
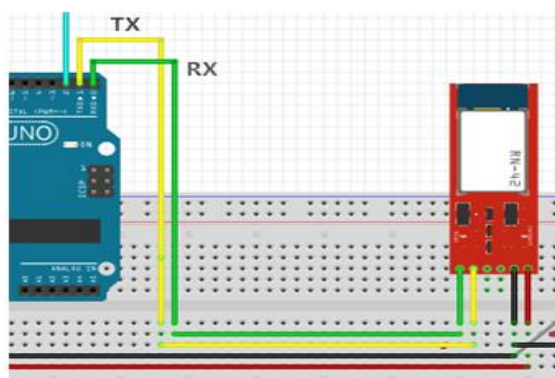

Figure (7) Schematic Diagram of Bluetooth Module Connection to Arduino UNO

There has been using actuator (12v) mounted on door used to lock/unlock operation. The actuator has driven by driver circuit designed by using transistor

as switching mode and relay (5v) connected to one of digital pin of Arduino UNO as shown in figure (8).
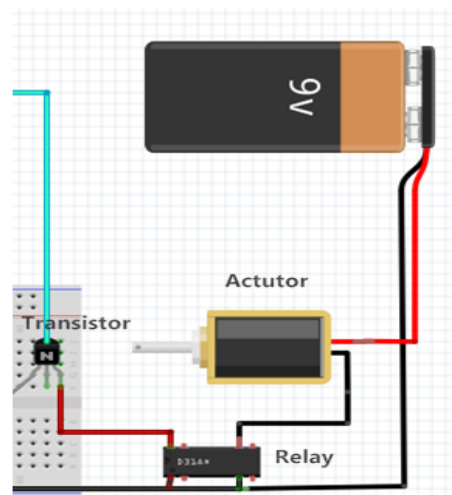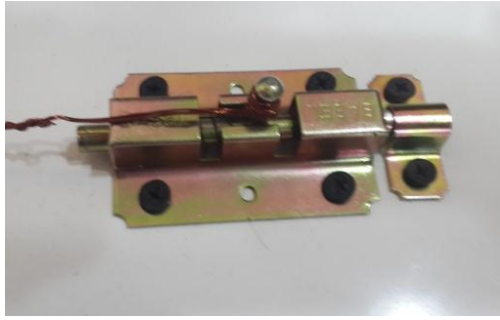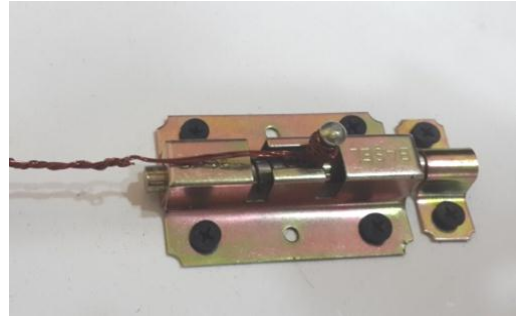

Figure (8) Actuator Driver Circuit Design

There are two types of actuator which are switch *on* and *off* depending on command sent by smart-phone. Each state of actuator has represented as shown in figure (9).

(a)   (b)

Figure (9) Actuator Types, (a) Normally Close, (b) Open

4. Conclusions

Smart home technology is involved with various fields (security, power consumption, communication, etc). Security issue is becoming more important and developed day by day.

The suggestion in this paper is apply Jaro Winkler string comparison algorithm for an authentication for door access by lock/unlock the actuator mounted to door. The proposed design has focused on developing door lock using Android platform for design a remote control, and Arduino UNO as control circuit to receive password string sent by personal smartphone, then compared this password string with string already recorded in control circuit and take decision to lock/unlock the actuator of door based on threshold (>0.9).

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تصميم قفل باب ذكي اَمن معتمد على خوارزمية جارو وينكلر

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الملخص

يعتبر الأمن في الوقت الحاضر إحدى المواضيع المهمة وعلى وجه التحديد في تصميم المنازل الذكية, في هذا البحث, تم تكريس العمل على موضوع الموثوقية في تصميم قفل باب ذكي باستخدام تقنية مطابقة النص بالاعتماد على نص كلمة المرور.

يحتوي هذا العمل على جزئيين اساسيين وهما برنامج الاندرويد الذي يعمل كمتحكم عن بعد ودائرة التحكم باستخدام اردوينو اونو , بالأضافة الى ذلك وسيلة الاتصال هي البلوتوث لغرض إرسال و استلام المعلومات و الأوامر .

الغرض الرئيسي من تصميم قفل الباب الذكي باستخدام خوارزمية جارو وينكلر هو مقارنة كلمة المرور المسجلة مع كل كلمة مرور مدخلة و التي قد تحتوي على بعض الأحرف الغير الصحيحة او لها موقع يختلف عن ما موجود في كلمة المرور المسجلة. أظهرت النتائج موثوقية عالية في الولوج في الوقت الحقيقي.