Automatic Recognition of User Drawn Graphical Passwords

Salem Jebriel and Ron Poet

School of Computing Science, University of Glasgow

Introduction

Text based passwords suffer from a major problem that memorable passwords are not very secure and secure passwords are not very memorable [3]. In other words, there are not enough different memorable text passwords. Graphical passwords have been proposed as an alternative since images are easier to remember than text phrases [1]. In other words, there are a large number of different memorable graphical passwords.

There are two major types of graphical password systems: recognition and recall based [5]. In a recognition based system, the user has to recognise their own graphical password from a collection of other images. In a recall based system the user has to remember their pass image and reproduce it when they log in. A text based password is a recall system since the user has to remember their password. Similarly, a paper signature is an example of a recall based image password. The user has to reproduce their signature to sign a document.

This paper focuses on recognition based systems. One advantage of a recognition based system over a recall based system is that it is easier to recognise an image when shown it again, rather than recreate it again from scratch [7], [2]. One disadvantage is that an attacker is shown the actual pass image and just needs to guess which is the correct one from a collection of distractor images. The security of these systems has been widely studied [4], [9] and is not the subject of this paper. A wide variety of types of images have been tried, including pictures, art and simple drawings [10]. Simple drawings form a distinct category because they are created by the user as a form of simple art, rather than being supplied or chosen by the user. The creative effort involved makes them easier to recognise again later [6].

One feature of all graphical password systems is that the effort needed to register the pass images is greater than that needed to register a text based password. They may be as easy to use and less error prone than text based passwords when the user logs in, but the initial effort needed to choose or create the graphical password may be a significant barrier to adoption. This paper describes ways of making the registration process easier.

Registration of User Drawn Images

One way of registering a user to a graphical password system is for the user to create their simple drawings on paper. The administrator then scans them in and registers them with the system. This is obviously labour intensive and a barrier to wide adoption of such a system. One way of eliminating the administrator role is to let the users scan in their artwork and register the resulting image file. There are many ways in which the user could get this wrong and so the system must be able to detect and correct these mistakes automatically. Software must be able to replace the human administrator. There are two parts to this software. One part must be able to guide the user through the registration process, since a human will not be on hand to offer advice and correct errors. The second part of the software takes the submitted

image file and detects and corrects any errors. It can be assumed that many users will ignore any guidance provided when they create and submit their pass image.

Alternatively, a user may use a computer drawing tool to create their pass image. This bypasses the scanning stage, eliminating some of the possible errors. However, it is harder to create an image with a mouse than a pencil, and users may find it harder to create a pass image that they like. Once again, the system must provide guidance when the user creates their pass image, and image analysis to detect and correct and flaws in the submitted image.

We built a system to explore automatic registration of simple drawings and ask a number of questions:

1. How effectively can users be guided through the registration process?
2. How effective is our image analysis software at detecting and correcting user mistakes after scanning drawn images?
3. How effective is our image analysis software at detecting and correcting user mistakes after submitting an image created by a computer drawing program?
4. Which method of providing their image did users prefer?

Experimental Procedure

A website was built using PHP and MySQL and hosted on www.passdoodle.net. It collected and stored basic information about the user and logged times spent by the user on all aspects of the experiment, including successful and failed login attempts. The website contained detailed instructions, including video clips, which explained all the steps the user had to perform.

The participants initially met with the experimenter who explained what they had to do. They were given an information sheet with the details and signed a consent form. They were asked to use any available internet connection, such as home, work or an internet café. They were asked to create an account with the passdoodle web site and submit their drawing either there and then or during a later session. After the account was successfully created, they were asked to log in three times, being prompted by an email from the experimenter. Lastly, they were asked to fill out a questionnaire. In detail, the experimental stages were:

1. Create an account for the first system
2. Register drawings for the first system
3. Create an account for the second system
4. Register drawings for the second system
5. Login to both systems (after 2 weeks)
6. Login to both systems (after 2 weeks)
7. Login to both systems (after 4 weeks)
8. Fill in and return the questionnaire

Half of the students scanned in their drawings first and the other half used the paint program first. This removed any temporal bias in the system.

A Java program was written to process the images that had been submitted. This was initially tested with a number of hypothetical mistakes that users could make. It was then tested with the real user mistakes. When participants used the scan system they first printed out a sheet of paper with guide marks. They drew their pass

images on this sheet before scanning and uploading it. The guide marks simplified the post processing of the image.

The participants were recruited from different schools in the University of Glasgow. 52 completed the pre-registration phase where they created an account. 41 then completed the experimental stages and 37 returned the final questionnaire.

Effectiveness

The effectiveness of the system was measured by the percentage of participants who were able to complete all the tasks without dropping out. The numbers completing each stage is given in Table 1.

Task	**Number Completed**
Create Accounts	52
Register using Paint	41
Login using Paint	39
Register using Scan	40
Login using Scan	40
Return Questionnaire	37

Table 1. Task Completion

The completion rate using the Paint system is 95% and 100% for the Scan system. According to [8], a technology is effective provided less than 5% of its users will have technical issues. Both of the systems are effective by this definition.

Efficiency

Efficiency measures the times needed to complete each task and sub-task. A system is efficient if a participant is able to complete tasks in a reasonable amount. This will depend on the context and what a user will think is reasonable. In this experiment, we compare the times for each task and can compare the efficiency of each task and so do not need to consider what a user would find reasonable. Our results are reported in Table 2.

Task	**Time (min:sec)**
Create Accounts	1:46
Register using Paint	9:00
Login using Paint	0:47
Register using Scan	16:00
Login using Scan	1:07

Table 2. Average Times to Complete Tasks

It takes longer to register with the scanner than to create the drawing in the paint system.

Success Rate

The login success rates are shown in Table 3.

	Paint	Scan
Login 1	92.3	92.5
Login 2	94.5	94.8
Login 3	90.9	86.1
Average	92.6	91.1

Table 3: Login Success Rate

Our research was focussed on the registration process and so the subsequent authentication stages were less important. They were there mainly to give a reason for participants to register their pass images at all. The success rates are consistent with other work in this area in that frequent use (the short time between login 1 and login 2) increases the success rate and infrequent use (the longer time between login 2 and login 3) decreases it.

Satisfaction

Satisfaction was measured by the questionnaire. All responses were on a 7 point Likert scale, with 7 corresponding to most agreement with the question and 1 least. All 37 participants answered all questions. The results appear in Table 4.

Questions	Median	Mode
1. I would like to use this website frequently	4	4
2. I found the website unnecessarily complex	2	1
3. I thought the website was easy to use	6	7
4. I would need the support of a technical person to use this website	1	1
5. I found the functions on this website were well integrated	5	7
6. I thought there was too much inconsistency in this website	2	2
7. I think most people would learn to use this website quickly	6	7
8. I found the website very cumbersome to use	2	1
9. I felt very confident using the website	6	7
10. I needed to learn a lot of things before I could get going	2	1

Table 4. Questionnaire Responses

Apart from question 1, all the positive (odd) questions scored highly and all the negative (even) questions had low scores. Thus the participants were satisfied with

the website. Question 1 was less relevant because the website did not have any interesting content.

User Preference

The final part of the questionnaire asked users which method of creating the drawing, scanning a paper drawing or the paint system, they preferred. The was followed by an open question asking them to give the reasons for their choice.

84% preferred the Paint system and 16% the Scan system. The advantages and disadvantages were as follows:

Scan – Advantages

Drawing was accurate
Very personal, in own hand writing
Reliable
More effective
Quicker to draw on paper

Scan – Disadvantages

Hand writing may be recognised by relatives
More complicated
No privacy, since paper drawing is produced
Takes a long time
Equipment problems

Paint – Advantages

Quick and easy to draw
Does not need special equipment
Hard to distinguish, good for security

Paint – Disadvantages

Hard to draw with a mouse
More time is needed for a good drawing

Errors During Scanning

As expected, many of the participants did not follow the instructions exactly and thus uploaded files that contained errors. A sample is shown in Figure 5.

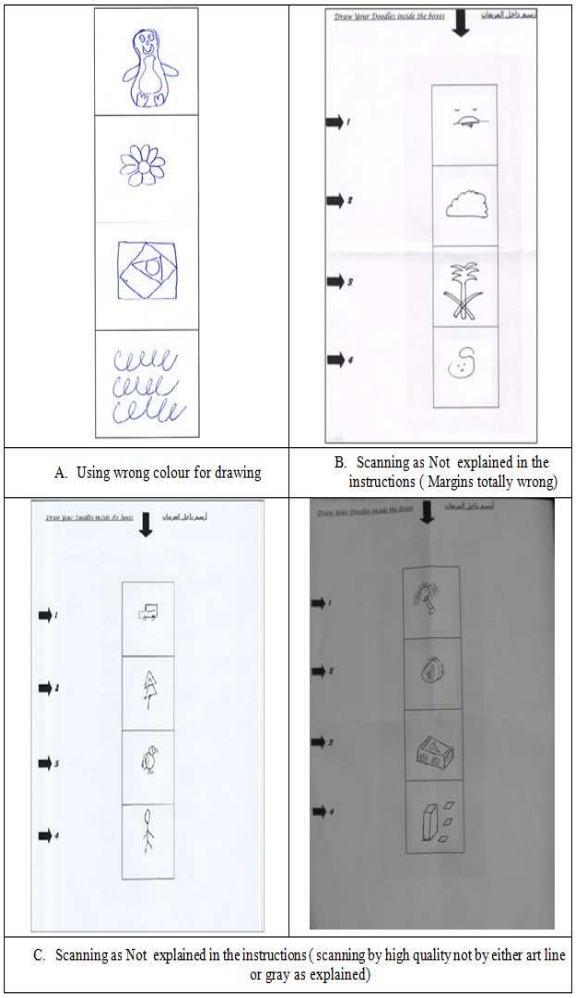

Figure 5. Some Errors while Scanning

As can be seen from Figure 5, the form for drawing pass images contained 4 boxes, one for each image. This allowed the image processing program to correct for slanted and upside down images, and to separate the original file into 4 separate image files. Example (A) shows that a user has used a blue pen rather than a black one. The analysis software converts a colour image to a black and white one using a threshold scheme based on individual pixel values, and so had no trouble automatically converting blue to black. The margins were wrong in file (B), but the image boxes enabled the software to locate the drawings anyway. File (C) was scanned at too high a quality, which was corrected by lowering the resolution while not losing any black pixels. File (D) shows that the drawing was done on grey paper. The pixel threshold scheme corrected this error. The image processing software managed to correctly extract most of the images from the scanned drawings. Some users drew images that were too big for the boxes. Our software correctly located the bounding boxes and cropped these images. One solution to this problem would be to make the boxes bigger.

Errors Using the Paint Tool

It was also possible for the participants to generate incorrect images using the paint tool. Some of these errors are shown in Figure 6.

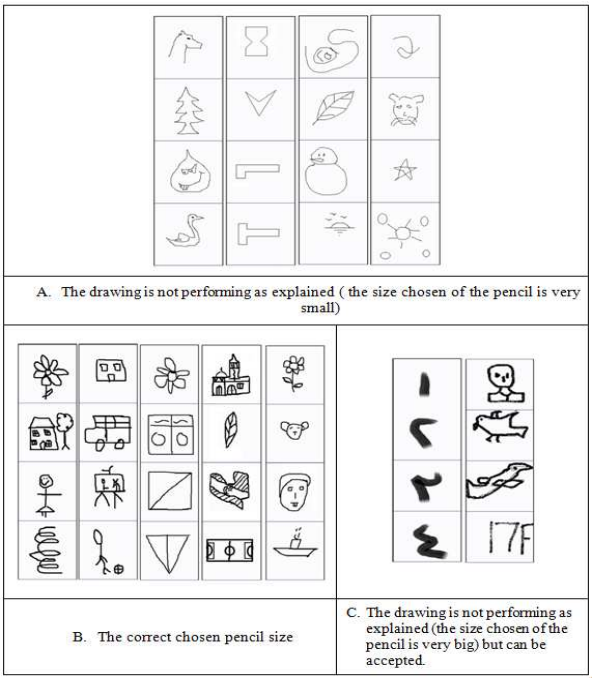

Figure 6. Errors Using Paint

The main error was in the point size of the pencil. Thick lines are fine, but thin lines can cause problems when the images are displayed during the authentication phase. Our software automatically thickened all the lines, and indeed black regions, of the submitted images, which corrected the problems shown in File (A) of figure 6.

Conclusions

Let us revisit the questions we asked at the start of the research.

How effectively can users be guided through the registration process?

95% of the participants who registered a pass-image completed the experiment. However, 21% created an account and then did not submit a pass image. The reasons for dropping out could not be determined. It could be that they were not very committed to using the website because it did not house any useful content. Alternatively, they could have found the instructions confusing. However, 79% did complete the registration stage successfully. This area warrants further study.

How effective is the image analysis software?

The software worked very well and was able to detect and correct almost all of the errors that users made when submitting their scanned file. The software worked equally well with scanned images and those produced by a paint program.

Which method of providing their images did users prefer?

The main conclusion of this research is that the participants would prefer to use a paint system rather than pencil and paper to generate their pass images.

Implications

Graphical passwords are beginning to be deployed on smart phones and this research is relevant in this context. Smart phones have a camera which can be used to take a picture of the drawings and upload it to an app. This replaces the scanner, and

is more convenient to use. Users would tend to make the same mistakes and so the same image analysis software can be used to detect and correct them. There is one addition error that would probably be common, that of perspective distortion caused by the camera not being exactly square on to the paper. This can be detected from the distorted shape of the boxes on the supplied form, which would have to be printed, and then corrected. There are many drawing apps available on phones, with the finger replacing a mouse. These would replace the paint program in our experiment. Our study indicated that users would prefer to use a drawing app to construct their pass images, rather than draw them on paper and take a photograph.

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