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A Survey on Different CAPTCHA Techniques

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ABSTRACT

Security researchers devised many mechanisms to prevent adversaries from conducting automated network attacks. One of the mechanism to prevent the network attacks are CAPTCHAs (Completely Automated Public Turing test to tell Computers and Humans Apart). There are different types of CAPTCHAs we can see in the websites now a days. Every CAPTCHA have its own techniques to provide security. In this paper we compare and evaluate the performance of different types of CAPTCHAs based on their security and usability.

KeyWords: Activity Recognition, CAPTCHA, Security ,Spatial Perspective, Usability.

1. INTRODUCTION

A **CAPTCHA** (**C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part) is a type of challenge-response test used to determine whether the user is human or not. Computers cannot decode the distorted words in a CAPTCHA easily, while humans can easily decipher the text. In the most common type of CAPTCHA user is provided with letters of a distorted image. Then the user solves the CAPTCHA by entering the correct characters. By definition CAPTCHAs are fully automated, it requires little human maintenance. A good CAPTCHA will have two characteristics such as usability and security. Security means the strength for preventing the variant attacks, while usability means the user friendliness of the CAPTCHA.

CAPTCHA has many advantages. First one is, it is used to prevent degradation of the quality of service of a given system, due to abuse or resource expenditure. Second one is, it protects the systems vulnerable to e-mail spam and stop automated posting to blogs and forums [1]. Because of these advantages of CAPTCHA, the applications include Preventing Comment Spam in Blogs, Protecting Website Registration, Protecting Email Addresses from Scrapers, Online Polls, Preventing Dictionary Attacks, Search Engine Bots, Worms and Spam [2]. In early days CAPTCHA provides high security, but now due to the growing technologies CAPTCHAs are vulnerable to many kinds of attacks. Many software programs can attack CAPTCHA efficiently. OCR is such a software program.

In this paper we compare and evaluate the performance based on usability and security of different types of CAPTCHAs. The remainder of this paper is organized as follows: section 2 includes the features of different CAPTCHAs. The performance evaluation of different CAPTCHA's is described in section 3 and we conclude in section 4.

2. CAPTCHA VARIANTS

There are different types of CAPTCHAs such as image based, text based, 3D, audio, question based etc to provide security. In this section we describe the features of different types of CAPTCHAs.

2.1 Image based CAPTCHA

In image based CAPTCHA users need to perform an image recognition task. The idea is to use images to make the CAPTCHA more difficult to recognize by bots. The recognition is very difficult in this CAPTCHA because of having colors in all pixels and also having huge variety of meaningful images. This require users to identify simple objects in the images

presented [3]. Picture identification CAPTCHA, human emotion based CAPTCHA, scenario based CAPTCHA etc come under image based CAPTCHA [4]. The Picatcha provides the user with an elementary choice of choosing the correct image that they are asked to identify. In human emotion based CAPTCHA a statement or a graphic is displayed to the user. User has to type a string describing his emotion as an answer. The idea behind scenario based CAPTCHA is to utilize the analytic and understanding capability of humans rather than merely recognizing objects [4].

In image based CAPTCHA, we concentrate on the features of interactive CAPTCHA and activity recognition CAPTCHA.

Interactive CAPTCHA

Interactive CAPTCHA requires a user to solve a CAPTCHA test via a series of user interactions**.** In this, first a normal CAPTCHA image with some background clutter is dynamically generated and displayed. The user clicks on the CAPTCHA image. When the CAPTCHA image is clicked, several buttons with obfuscated characters appear below the CAPTCHA image. Then the user must click on the button corresponding to the first character in the CAPTCHA image. Upon each click, a new set of buttons is rendered. This input sequence continues until one click has been performed for each character of the CAPTCHA image. On the server side, session information is stored about the indices of the correct responses and the indices of the user clicks. After completing the input sequence, it is compared with the correct index sequence. If there is a match, the CAPTCHA has been correctly decoded by the user[5].

To provide security interactive CAPTCHA measures the time it takes for a user to respond on a per-character basis. Therefore, the per-character timeout for interactive CAPTCHA can be set much lower than the timeout value for a standard CAPTCHA. This provides a much greater resolution in determining human attacks because the relative time between each input and the time it takes to send the CAPTCHA to a human solver is minuscule. Interactive CAPTCHA allows users to take as much time as needed to decode the image first before starting the multi-step challenge/response sequence. The limitation of interactive CAPTCHA is it is not suitable for blind people[5].

Activity Recognition CAPTCHA

In this CAPTCHA test the users are provided with the images of a common activity. The images are distorted to a certain extent. The users have to decode the activity to solve the CAPTCHA an pass the test. The activity or solution is stored in the database. The user's solution is same as the one stored in the database then they can pass the test, otherwise failed. Sometimes misspelling can occur while solving the CAPTCHA. So to avoid this, the user is provided with a list of activities. Then the user can select the common activity associated with the images[6].

The advantages of these type of CAPTCHAs are:

- Activity CAPTCHA is universal. Because the activity lists using an English word is common in all countries.
- Misspelling problem will not occur.
- Users need not have to familiar with the English words to pass the test.
- Difficult to attack.
- CAPTCHA test is robust by using the dynamic database[6].

The disadvantages of these types of CAPTCHAs are:

- Not suitable for blind people.
- Difficult to decode the CAPTCHA by the users having learning disabilities[6].

2.2 Text based CAPTCHA

The text based CAPTCHA is based on alphabets and numeric values. Certain distortions and noise are added to prevent bot attacks, while recognizable to human eyes.[4] There are several properties for the CAPTCHA text. They are:

- **Font** refers to the typeset and size of the text.
- **Character set** refers to the collection of characters used in a particular CAPTCHA.
- **Distortion** is the use of attractor fields which alter the image by changing the relative location of pixels.
- **Tilting** is the rotation of characters to different angles throughout a CAPTCHA image.
- **Waving** refers to positioning tilted characters at various vertical locations creating a wave pattern with the textual foreground[4].

Time based and sentence based CAPTCHAs are two categories of text based CAPTCHA. In time based CAPTCHA the user have to type the flash alphabets at different locations of the screen in small intervals

of time, in the sequence in which they appear. These CAPTCHAs expire, if they don't receive a response in a particular time interval. Idea behind this is to make use of challenges which humans can solve quickly but computers take some time to solve. In sentence based CAPTCHAs after selecting two random words from a sentence, they are swapped. Then a random alphabet is filled in each whitespace present in the sentence. Then the user have to write the sentence in the correct format[3]. A type of text based CAPTCHA includes clickable CAPTCHA is discussed below.

Clickable CAPTCHA

Clickable CAPTCHAs are text based CAPTCHAs used to simplify and speedup the entry of CAPTCHA solution. The entering of CAPTCHA solutions on a mobile device is difficult and time consuming while comparing to a keyboard. So the clickable CAPTCHAs are very suitable and safe to mobile phones. Clickable CAPTCHAs combines several textual CAPTCHAs into a grid. The solution to a clickable CAPTCHA is the determination of the grid elements which satisfy some given requirement. The selection can be done with a mouse, a stylus, or even a cell phone keyboard. If the solution of clickable CAPTCHAs is set as three English words, then the user must select the three English words through three clicks from the grid. Only three English words will be present in the grid. Other portions contain meaningless words. If the user click any CAPTCHA other than the meaningful one, then the solution is invalidated. So this CAPTCHA provides security against computer attacks[7].

Clickable CAPTCHAs provide more security and also usability. So it can be used in many applications. It can be solved faster with cell phone screen and keypad than regular CAPTCHAs.

2.3 3D CAPTCHA

3D CAPTCHA is a technology based on spatial perspective and human imagination. The basic idea is rotation of a special 3D model and finding the correct position of rotation[8]. The separate parts of 3D model are created from any 2D picture. These are then projected into 3D space. These elements together generate a 3D model in space. Elements are reflected into the space randomly. The task of a solver of the CAPTCHA is to rotate the model and find the correct observation point. The right solution is basically only guessed by the user[8].The only way to solve the 3D CAPTCHA test is to use the human imagination. A key task in 3D CAPTCHA is to incorporate human abilities and characteristics into the technology which cannot be done by computer systems[8]. The features of a type of 3D CAPTCHA known as interactive 3D CAPTCHA with semantic information is given below.

Interactive 3D CAPTCHA

The interactive 3D CAPTCHA that makes use of semantic information and commonsense knowledge. This 3D CAPTCHA consists of an empty space containing several different 3D objects, which can all be manipulated using the mouse, to rotate, move and resize. They have different colors, textures, shapes and sizes, and some of them share one or more of these features. The features are chosen randomly in order to make the scene less predictable. The source of light also moves and changes color, causing further difficulties for object recognition. These existing 3D CAPTCHAs are vulnerable as they are usually grayscale or don't use alternating textures[9].

In this interactive 3D CAPTCHA the user is asked to identify a small selection of objects based on a semantic description. Each object has its own list of descriptions pertaining to that object only, many of which are based on commonsense knowledge. Each object carries a letter or a short string of letters or other symbols possible to reproduce placed somewhere on its surface, ideally where it's initially not visible to the user. Thus, the user needs to rotate and possibly resize the objects to reveal these symbols. It is possible to program a bot to interact with a 3D environment in this manner.[9]

2.4 Audio CAPTCHA

Audio CAPTCHA picks a word or a sequence of numbers at random, renders the word or the numbers into a sound clip and distorts the sound clip. It then presents the distorted sound clip to the user and asks users to enter its contents. This CAPTCHA is based on the difference in ability between humans and computers in recognizing spoken language[4]. Audio CAPTCHAs is used as alternative for those unable to use the more common visual CAPTCHAs. But these CAPTCHAs are more difficult to solve. Current CAPTCHAs rely on superior human perception, leading to CAPTCHAs that are predominately visual and, therefore, unsolvable by people with vision impairments[10].

In audio CAPTCHA, text is synthesized and mixed in with background noise, such as music or unidentifiable chatter. Audio playback is linear. Sometimes audio CAPTCHAs are difficult for blind web users. Audio CAPTCHAs could also be made more understandable, but that could also make them easier for computers to solve automatically. So by using some techniques we can improves usability without changing the underlying audio CAPTCHAs[10]. The features of an audio CAPTCHA that increases usability is discussed below.

Audio CAPTCHA with a User Interface

This is a type of audio CAPTCHA that eliminates the difficulty in solving the CAPTCHA while increases the usability using an user interface. Here the usability increases without changing the underlying audio CAPTCHAs. . A solver of an audio CAPTCHA first plays the CAPTCHA and then quickly focuses the answer box to provide their answer. For sighted solvers, focusing the answer box involves a single click of the mouse, but for blind solvers, focusing the answer box requires navigating with the keyboard using audio output from a screen reader. Solving audio CAPTCHAs is difficult, especially when using a screen reader By moving the interface for controlling playback directly into the answer box, a change in focus is not required. Using the new interface, solvers have localized access to playback controls without the need to navigate from the answer box to the playback controls. Solvers also do not need to memorize the CAPTCHA, hurry to navigate to the answer box after starting playback of the CAPTCHA, or solve the CAPTCHA while their screen readers are talking over it. Solvers can play the CAPTCHA without triggering their screen readers to speak, type their answer as they go, pause to think or correct what they have typed, and rewind to review all from within the answer box[10].

2.5. Logic Question based CAPTCHA

In Logic question based CAPTCHA some simple questions will be asked to users prior to accessing the website. This is also called math solving CAPTCHA. If the users can't solve these basic math problems then they can't access the website. These provide users with easy to read numbers that must be added in order to get past the CAPTCHA[11]. The features of a logic question based CAPTCHA is discussed below.

Question based CAPTCHA

This CAPTCHA is a combination of OCR and Non-OCR based CAPTCHA. In this type of CAPTCHA a simple mathematical problem is generated according to a predefined pattern. Then the whole problem is saved and shown to the user in form of an image for answering. For answering this problem requires four abilities. They are: understanding text of question, detection of question images, understanding the problem, and solving the problem. A human user can answer this question and present computer programs are unable to solve it[12].

This CAPTCHA can be solved by humans easily because they only want to remember the answer of the image, so it requires only little time[12]. It is very difficult for computer program to solve the CAPTCHA because it must recognize the phrase, size, shape and text of an image. even if the computer program get all the above datas it must be capable to answer the shown question. Advantages of this method are:

- Easy to use, saves user time.
- In this method it is not necessary to have a keyboard**.**
- Client side processing can be avoided and can be executed on devices with limited resources[12].

3. PERFORMANCE EVALUATION

To evaluate the performance of CAPTCHAs we compare the different CAPTCHAs such as image based, text based, question based, audio based and 3D CAPTCHA. The purpose was to determine which CAPTCHA gives better performance against third party human attacks. While evaluating the different CAPTCHAs we identified that different CAPTCHAs have their own ways to prevent third party human attacks.

In image based CAPTCHAs, the basic technique to prevent the third party human attacks is adding background clutter and distorting the image. Interactive CAPTCHA uses a set of buttons to solve the CAPTCHA, while activity CAPTCHA uses a list of activities to solve the CAPTCHA. The interactive CAPTCHA's security mainly depends on the time of the user's interaction with the CAPTCHA, while the

activity CAPTCHA's security depends on the commonsense of the user. A user other than a human cannot solve these two CAPTCHAs.

In text based CAPTCHAs the security is based on different arrangement of each character in the text by providing different angles of rotation and or in an overlapped form. The user have to decode the text to solve the CAPTCHA. In Clickable CAPTCHA a number of text based CAPTCHAs are combined and used. The security of this CAPTCHA depends on the ability of the user to decode the meaningful English words. Only literate people can solve this CAPTCHA.The interactive 3D CAPTCHA's security depends on the common sense of the user. The user will be provided with some 3D objects and some clues to solve the CAPTCHA. The 3D CAPTCHAs are very difficult to solve and it cannot be solved by illiterate.

Question based CAPTCHAs are based on the user's ability to answer the questions. In this CAPTCHA also commonsense is a main factor. The above described question based CAPTCHA has some relation to image based CAPTCHA also, because questions are some images. Evaluating the audio CAPTCHAs we identified that this is a CAPTCHA that has many differences from other CAPTCHAs. The CAPTCHA is mostly preferred to the blind people. But it is difficult to solve. The security depends on the noise added to the audio. The above described audio CAPTCHA an interface is used to reduce the difficulty to solve the CAPTCHA.

While comparing these CAPTCHAs we identified that all the CAPTCHAs can prevent the computer program attacks. The CAPTCHAs can also prevent the human attacks by different methods. The two main important requirement of a CAPTCHA is usability and security. So we can evaluate the effectiveness of CAPTCHAs based on usability and security. The Table 1 shows the comparison of different CAPTCHAs.

From the table we can understand that image based CAPTCHAs are good in case of security and usability. It is very much secure and easy to solve. All others CAPTCHAs show less performance in the case of either usability or security. The only disadvantage of image based CAPTCHAs are ,it is not usable for blind people. The only CAPTCHA which is usable for blind people are audio based CAPTCHA, which is difficult to solve. So it is not a user-friendly.

Table 1: Comparison Of CAPTCHA's

Type of CAPTCHAs	Security	Usability	
		Easy or difficult to solve	Usable for blind
Image based	Good	Easy	No
Text based	Average	Easy	No
3D CAPTCHA	Good	Difficult	No
Audio based	Good	Difficult	Yes
Logic Question based	Average	Easy/difficult	No

4. CONCLUSION

CAPTCHA (Completely Automated Public Turing Test to Tell Computers and Humans Apart) is a simple test that is easy for humans but extremely difficult for computers to solve. In this paper various CAPTCHAs are compared in different aspects iCAPTCHA system provides simple and effective defense against 3rd party human solver attacks. The clickable CAPTCHAs will simplify and speed-up the entry of the CAPTCHA solution. Activity Recognition CAPTCHA is a test in which the user is presented with a set of distorted images that represent a randomly chosen activity. The user need to recognize the common activity associated with the images. Interactive 3D CAPTCHA makes use of semantic information and commonsense knowledge. Audio CAPTCHAs is used as alternative for those unable to use the more common visual CAPTCHAs, but these are difficult to solve. In Question based CAPTCHA a simple mathematical problem is generated according to a predefined pattern and then the whole problem is saved and shown to the user in form of an image for answering. From the comparison we identified that image based CAPTCHAs have good performance.

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