

IMPLEMENTATION OF COGNITIVE CAPTCHA SECURITY FOR WEB APPLICATIONS

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Abstract— Captcha stands for Completely Automated Public Turing test to Tell Computers and Humans Apart, a standard security mechanism in every web based applications used to differentiate humans and bots. Various Captcha security methods such as text, image, video and audio based methods have emerged over the years. All the traditional Captcha methods are frequently suffered by OCR attacks, laundry, brute force, pixel count and other automated bot attacks. Humans smash computers and robots in cognitive activities. In this way cognition based Captcha security methods becomes popular and replaces the traditional Captcha methods in web applications. This paper analyzes the various cognition based Captcha security methods employed in different web applications and their merits and demerits.

Index Terms— Captcha, OCR, Cognition, Web security, Bots.

I. INTRODUCTION

Captcha also known as HIP [15] employed in all the websites as a security arrangement which distinguishes humans and computer bots automatically. Captcha protects web sites and web applications from the illicit entry of the automated computer programs called as bots. Thus Captcha prevents the bot programs from doing any malicious activities in the Internet applications. The various types [16] of Captcha are,

- Text based Captcha
- Image based Captcha
- Video based Captcha
- Audio based Captcha

The text based Captcha are very popular and employed in most of the web applications. It is a widely accepted method by all section of users because of its simplicity and user friendliness. Gimpy, Ez Gimpy, MSN, baffle text, Pessimial print and handwritten Captcha are the popular text based Captcha methods. Image based Captcha methods are designed to prevent any type of OCR attacks, which is one of the prime threat to the text based Captcha. Bongo, ESP PIX, kittenauth and Assira are the popular image based Captcha

methods. In addition, audio based Captcha are also introduced for the benefit of visually challenged people similarly for hearing impaired people the video based Captcha methods are devised. A perfect Captcha method must satisfy the following properties.

- Usability: It should be easy for humans to solve.
- Robustness: It should be hard for the malicious bot programs to break.
- Scalability: Measurement of number of challenges that a Captcha method can generate without conceding the robustness and usability

II. CAPTCHA ISSUES

The Captcha images are attacked in numerous methods by hackers to perform malicious functions in web applications. Automated bot attacks on the traditional text, image, video and audio Captcha methods become a challenge for the web security. The common Captcha attacks are,

- *OCR software attacks* – By using OCR software [17] the hackers attack the Captcha images to gain access into the web service. The latest OCR software almost identifies any type of text based Captcha image. It is the prime threat to the text based Captcha.
- *Paid Human solvers or relay attacks* - A bot gather the Captcha image from the signup page and send it to the paid human solvers in a remote place. They solve the Captcha and send back to the bot, to gain access into the website.

Laundry attacks, Brute Force Attack, Pixel Count Attack and Dictionary attacks are also become a threat to the Captcha security. Hence instead of the traditional Captcha methods, novel methods with more security become essential. Cognitive abilities are the brain based skills,

human only posses. Implementation of cognition based Captcha methods will enhance the security and usability more efficiently and intensify the response to the emerging threats. The cognition based Captcha security methods include and combine cognitive activities of humans with the traditional text, image, audio and video Captcha.

III. COGNITION

Cognition is an intellectual action or process of gaining knowledge and understanding by thought, experience and senses. It comprises the processes such as knowledge, concentration, memory, working memory, judgment and assessment, reasoning and computation, problem solving and decision making. Human cognition is mindful and unconscious, concrete or abstract as well as instinctive and conceptual. Cognitive processes use existing knowledge and generate new knowledge. The various human cognitive activities are classified as,

- **Perception** – It is a process of recognizing and interpreting the sensitive stimulus - vision, hearing etc.
- **Attention** – Humans ability to sustain concentration on a particular object, action.
- **Motor skills (actions)** – Humans ability to mobilize their muscles and bodies. The process of manipulating the objects. Humans can perform mouse movements, click actions and circular movement, etc.
- **Visual and Spatial Processing** – It is an ability to process the incoming visual stimuli. Human's ability to understand the spatial relationship between the different objects. Ability to visualize images and scenarios.
- **Executive Functions** – Human ability to plan and execute a goal, which includes,
 - Anticipation: It is a prediction based on pattern recognition.
 - Problem solving: Humans ability to define a problem and to generate all possible solutions and pick the best one.
 - Decision making: Humans ability to make Decision in different situations.

IV. COGNITION BASED CAPTCHA SECURITY METHODS

Numerous methods of Cognition based Captcha are devised and employed in various web applications for the improvement of web security. Every method has some advantages and few limitations. Henry S Baird [1] developed a novel Captcha method known as implicit Captcha, which is free from any type of attacks. The standard text entry with

submit button has been replaced with a single mouse click. The user needs to concentrate on the displayed Captcha image and identify the answer from the choices or from the figure and then finally made a single mouse click on the answer to get authenticated. The mouse click cognitive actions are easy for humans and not possible for bots but simple mouse click actions are not sufficient and multiple cognitive actions are needed to prevent bot entry.

Elias Athanasopoulos and Spiros Antonatos [2] proposed novel animation Captcha using animated pictures. The concept of animation is to prevent the laundry attacks. In the laundry attack the hackers or the bot programs redirect the Captcha image to a malicious website to solve the Captcha. The malicious websites in some way attract the users and ask them to solve the Captcha before their original task or work. This can be prevented by the animated Captcha in which the image is continuously changing till the user identify and click the answer. Fig .1 shows the Implicit and Animation Captcha images.



Fig .1. Implicit and Animation Captcha images.

Arpan Desai et al [3] introduced a new cognition based drag and drop Captcha. In which a random seven character text is displayed to the user. But the user was not permitted to type Captcha characters. Instead the user has to drag and drop the character in the respective blank boxes provided on the user screen. For dragging operation a set of required character blocks is also provided. The cognitive drag operation improves the security. But the usability is decreased with the twisted Captcha characters, which give annoyance to the users. The execution time also increased because of the drag function.

Deapesh Misra and Kris Gaj [4] proposed face recognition and matching as Turing test. Recognizing the human face is a tough task for computers, but it is relatively easy for humans. In the proposed method, human face photographs from public database are distorted and displayed to the user in two different formats. The user is asked to match the photographs, for authentication. Identifying human faces and matching can be possible only for humans with cognitive perception activity. The Bot programs unable to perform a matching operation of human faces from the set of given images, hence authentication is denied. This method also needs a large database of human faces. Creating distortion may deface the original images; hence identification and matching will become difficult for the users. Sometimes it may create confusion when identical

images like twins are presented. Figure 2. shows the Drag and drop, face image matching Captcha methods.

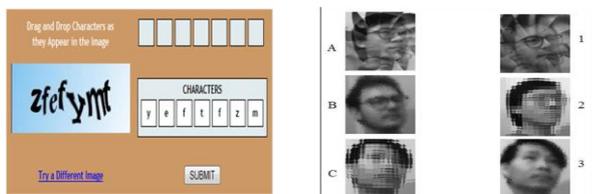


Fig 2. Drag and drop, Face image matching Captcha

Puzzle solving is one of the hobbies for humans. Nitisha Payal et al [5] proposed this interesting concept as puzzle Captcha. In this a Jigsaw puzzle is displayed to the user. The user is asked to solve the Jigsaw puzzle to get authenticated. The users need to arrange and interlock the small image piece which finally produces a complete picture. It is almost impossible for the bots to understand this concept and the images and their sequences in the puzzle. But this method needs too many drag operations to complete the puzzle it will confuse the users and also too many position changes of image pieces will give annoyance to the genuine users. Even some human users are also unable to identify and solve the puzzle image.

Rich Gossweiler and Shumeet Baluja [6] proposed what's up Captcha, in this the users has to perform image orientation. A randomly rotated image is displayed to the user and the user has to rotate the image in upright orientation for authentication. Rotating images to their upright orientation is a difficult task for computers, and this is possible only for humans through cognitive skills. This method needs human motor skill cognition activity. Humans only can perform the sliding operation, hence security is enhanced. But confusion exists over the upright position of the image; the user will get confused in determining the exact position of the image. Fig.3. shows the Jig saw puzzle and image orientation Captcha images.

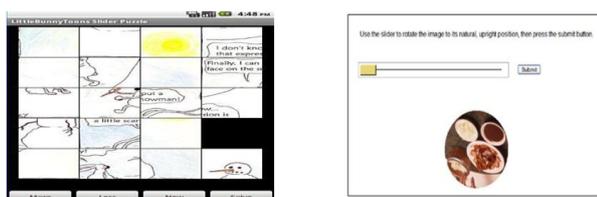


Fig.3. Jig saw puzzle and image orientation Captcha

Mohammad Javed Morshed Chowdhury and Narayan Ranjan Chakraborty [7] proposed a cognition based question Captcha. In this method, the user will be provided five domains for question selection, namely analytical, maths, general, text and image. Based on the user option a simple question will be generated randomly and displayed to the user, for correct answer. This method provides choice to select the domain for question, hence usability is increased. But only a limited number of questions in question bank will

lead to brute force attacks, also the user need to understand the question, which are lengthy and time consuming. While answering the question in words, may lead to spelling mistakes. Humans are very well aware of doing mathematical calculations and applying formulas for the equations.

Carlos Javier Hernandez-Castro and Arturo Ribagorda [8] devised a Captcha method, which displays a mathematical problem in user screen. The math Captcha is one of the novel cognition based approach. Computers are capable of solving math problems. But the math Captcha problem is displayed as an image; hence by perception only the problem can be solved. Understanding and solving the given mathematical problem in image format will be a tough task for bots to perform. Math Captcha is one of the highest security cognitive method, but the setback is normal human users can also be not able to understand the problem. Also differentiation and integration problems cannot be easily answered by the users those who do not have strong mathematical knowledge. The execution time of this Captcha is relatively high. Figure 4. Shows the Question and math Captcha images.

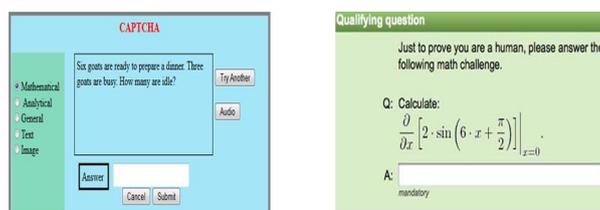


Figure 4. Question and math Captcha images.

Moin Mahmud Tanvee et al [9] proposed a two layer Captcha test based on human cognitive psychology. In the first layer user need to move and place the exact block of images rearranged randomly. In the second layer user need to select the event associated with the image from the drop down list to ensure more security. The mouse dragging cognitive actions are only possible for humans and it is almost impossible for the bots hence security is very much improved. However, we have only four goal image options which may lead to brute force attacks and sometime users may get confused in completing the goal image when the option images concept is not clear. Also the events associated with the goal images are also very limited.

Rituraj soni et al [10], proposed an improved Captcha method. In this approach image of an object is displayed on the left side of user screen and the name of the image are displayed in the right side. The users by perception look into the image and identify the name of the image and then enter the image name in the text box for authentication. In this method the image name is displayed on the user screen, hence verifying and typing the image name will become easier for users and this method avoid any spelling errors. Figure 5 shows the move and select and improved Captcha method images.



Figure 5. Move and select and Improved Captcha images.

Mandeep Kumaret al proposed a novel color image Captcha [11]. In this method, a color based image is displayed to the user and the user is asked to enter the color of the particular image or object. Single color as well as multicolor images is used in this approach. Color always attracts humans. Therefore this Turing test becomes enjoyable for humans. The user needs perceptual cognitive activity to complete this test.

Divya Shanker et al proposed an advanced hybrid collage Captcha [12]. In this two images, one on the left hand side called as goal image and another image on the right hand side consists of six option image with different names. The user has to match the left hand side image to the right side and enter the text below the image in the text box provided for authentication. Figure 6 shows the image of color Captcha and Hybrid collage Captcha.



Fig.6. Color Captcha and Hybrid collage Captcha

Takumi Yamamoto et al [13] proposed a cartoon Captcha. It is a new type of cognition based Turing test that uses four panel cartoons, which makes Captcha fun and enjoyable. The four panel cartoon presented to the user is rearranged randomly. The users need to arrange the cartoons in correct order to get authenticated. The figure 7 shows the concept of Cartoon Captcha.



Fig 7. Cartoon Captcha

Mir Tafseer Nayeem et al [14] proposed Emoticons Captcha, based on human cognitive psychology, as shown in Fig.8, in which the users need to identify the exact emoticon

from the set of option emoticons associated to the image and drag it the specified position to pass the Captcha test.



Fig.8. Emoticons Captcha

V. CONCLUSION

Artificial Intelligence becomes a real threat to the security of all the traditional Captcha methods. The security of a Captcha method is as similar to playing a game and staying ahead. The Captcha methods are also designed using artificial intelligence technology and bots cannot solve until someone teaches them to do it. But there are some things that can be done only by humans and not by any computer bots. Cognition is one such property human only poses. Humans are capable of processing the information by perception, knowledge and experience. Bots cannot perform cognitive activities using current AI technology. Hence cognition based Captcha methods ensure more security.

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