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REVIEW ARTICLE

IMPLEMENTATION OF 3-LAYER IMAGE CAPTCHAS TO AVOID DETECT TREMENDOUS ATTACKS

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ABSTRACT

The mainstay of this paper is to avoid tremendous attack from malicious computer programs using 3-D static CAPTCHA (Completely Automated Public Turing test to tell Computers and Human Apart) mechanism has been introduced to distinguish humans and computers. Though there are many different kinds of specific implementations for CAPTCHA. It requires users to identify images. Up to now, except some research sites, commercial sites rarely use it. Specific implementation algorithms are: CAPTCHA algorithm based on real object image identification and CAPTCHA algorithm based on image similarity judgment. Draw backs of 2D:Due to the fast development of pattern recognition and artificial intelligence technology, there are increasing safety loopholes concerning traditional 2D static CAPTCHAs, resulting in that certain malicious computer programs could launch serious program attack through breaking such CAPTCHAs. The authors, in this paper propose 3-D Dynamic CAPTCHA algorithm which is not only extremely hard to crack for computer programs using multiple frames, but also easy for humans to identify.

INTRODUCTION

In September 1999, www.slashdot.com conducted a survey to figure out in which university graduates of the department of computer science were the best (JIN Hai-kun and Wen-jie SHA Li-min, 2006). Although the voting system could prevent the same IP address from voting more than once, students from CMU wrote a program to make the number of votes for CMU go up rapidly. The next day, students from MIT adopted a similar approach, resulting in that the number of votes for either of these two universities far exceeded the other universities. Moreover, a report from the Barracuda Network Security Corporation in the USA said that in 2007 nearly 95% of the mails received by the world's Internet users were junk mails. Similar situations are registering user accounts maliciously, cracking account passwords with brute force, etc. All of these bring a great threat to the network. In order to prevent similar incidents from happening again, CAPTCHA mechanism comes into being, which is short for Completely Automated Public

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Turing Test to Tell Computers and Humans Apart (Luis von Ahn *et al.,* 2000; Luis von Ahn *et al.,* 2004). In 2000 Carnegie Mellon University set up the first CAPTCHA group, followed by many scholars studying CAPTCHA to find how to better tell between humans and computers apart. Currently, in order to prevent malicious programs from issuing advertisements or other useless information recklessly, message boards of BBS, blog and wiki have widely used CAPTCHA mechanism, requiring that users must input the correct letters to leave a message. CAPTCHA also plays a significant role in limiting usage rate. For example, the automatic use of a particular service is allowed unless such use goes beyond a certain extent and affects other users. When that happens, we can limit such usage through the introduction of CAPTCHA mechanism.

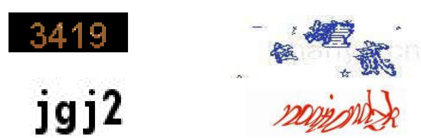
CAPTCHA is also used in a variety of online trading systems, such as online banks or reservation systems, to prevent malicious programs from trying a large number of dealings. Similarly, Email service systems such as Gmail and Hotmail, also introduce CAPTCHA mechanism to limit the frequency of registrations or logins to avoid troubles brought by tremondous junk mails. This paper is organized as follows. Section 2 presents an overview of related work on CAPTCHAs. The origin of 3-layer dynamic CAPTCHA design is discussed in Section 3. Then the specific design and implementation of 3-layer dynamic CAPTCHA is given in Section 4, followed by the security analysis of this new design in Section 5. Finally, a conclusion is given in Section 6.

II.RELATED WORK

Currently, there are mainly three kinds of methods to implement the CAPTCHA mechanism: OCR (Optical character recognition) visual method, non-OCR visual method and non-visual method. The D static CAPTCHA based on OCR visual method takes advantage of superiority in language barrier, security and easy use, becoming the most widely used CAPTCHA (von Ahn *et al.,* 2003), as shown in Fig. 1 (a). Commonly seen CAPTCHAs are: Gimpy series CAPTCHA designed by Carnegie Mellon University in 2000, Pessimal Print CAPTCHA designed by Henry Baird from PARC(Palo Alto Research Center) in 2000, and Baffle Text CAPTCHA designed by Baird in cooperation with Monica Chew from California Berkeley in 2003 (HU Jin-rong and WANG Ling, 2008). However with the fast development of OCR technology based on neural network, as well as the emergence of a variety of character segmentation technology, CAPTCHAs of lots of websites have been attacked. A Russian programmer has ever cracked the CAPTCHA mechanism of Yahoo with 35% success rate. Also, the CAPTCHA mechanism of Microsoft live mail has been bothered by junk mails many times. Given facts like these, newly designed CAPTCHAs have become increasingly complex, so that some of those are extremely difficult to identify, as shown in Fig. 1 (b).

Though there are many different kinds of specific implementations for non-OCR visual method, it eventually comes down to the OCR problem in general, requiring users to identify images. It is not so widely used. Up to now, except some research sites, commercial sites rarely use it. Specific implementation algorithms are: CAPTCHA algorithm based on real object image identification and designed by R. Datta, etc, CAPTCHA algorithm based on image similarity judgment and designed by J. Elson, etc, and so forth. Non- OCR visual method is designed for special occasions and certain user groups, thus it has very limited applications. Examples are: voice-based CAPTCHA algorithm intended for visually disabled people and designed by G. Kochanski, etc, CAPTCHA algorithm based on collaborative filtering and designed by M. Chew, etc, and so forth.

1In conclusion, the OCR-based 2D static visual method is the main way to implement current CAPTCHA mechanism. However, it could no longer strike a balance between security and easy use, calling for a new kind of CAPTCHA to address this increasingly prominent problem.



a) *(b)*

Fig 1. 2D staticCAPTCHA based on OCR visual method

III. ORIGIN OF THE DESIGN

Given the deficiencies of traditional 2D static CAPTCHA, we come up with the idea of 3-layer Dynamic CAPTCHA.

A. Origin of the Idea

In order to make it easy for humans to identify, images of traditional static CAPTCHA must contain sufficient valid information. However, the easier it is for humans to identify, the less security it bears in general. So we can not help thinking that if we distribute the valid information among multiple frames according to certain rules to make every single frame difficult to identify, and that if we can also make sure that it is still very difficult for computer programs to crack even using multiple frames, as well as easy for humans to identify, then the new design can pursue a better balance between security and practicality.

B. Security of Multiple Frames

In order to ensure that it is also very difficult to break for computer programs using multiple frames, we adopt the form of movement, thus reducing the crack of multiple frames to the problem solving of identifying and tracking moving objects from images. In current fields of artificial intelligence and image processing, the problem of identifying moving object is far more difficult than the OCR problem, particularly identifying and tracking multiple moving objects in a complex context , which is commonly recognized as an academic.

C. Easy Identification for Humans

Dynamic CAPTCHA can make it not only extremely hard to crack for computer programs using multiple frames, but also easy for humans to identify. According to anatomical, physiological and functional characteristics of the visual system, there are two visual pathways in the brain, the ventral pathway, which function is to identify objects, and the dorsal pathway, which function is to identify spatial location and movement of objects, as shown in Fig. 2. Both the identifiability and contrast ratio of images will affect moving objects. In the right hemisphere, 3D movement shows stronger brain activity than 2D movement. The biological vision theory says that the perception ability of moving objects far exceeds that of static objects for biological vision. For example, we can easily recognize a running cheetah in a jungle while could hardly notice a stationary cheetah in the jungle. The reason is that the human visual system can easily reconstruct the overall shape merely from vague displacements of parts of the moving object.

IV. SPECIFIC DESIGN AND IMPLEMENTATION

In order to make the design of dynamic CAPTCHA clearer to bear strong scalability and large space for optimization, we have further introduced the "layered" concept. Three layers of this design are: character layer, background interference layer and foreground interference layer, as shown in Fig. 3.

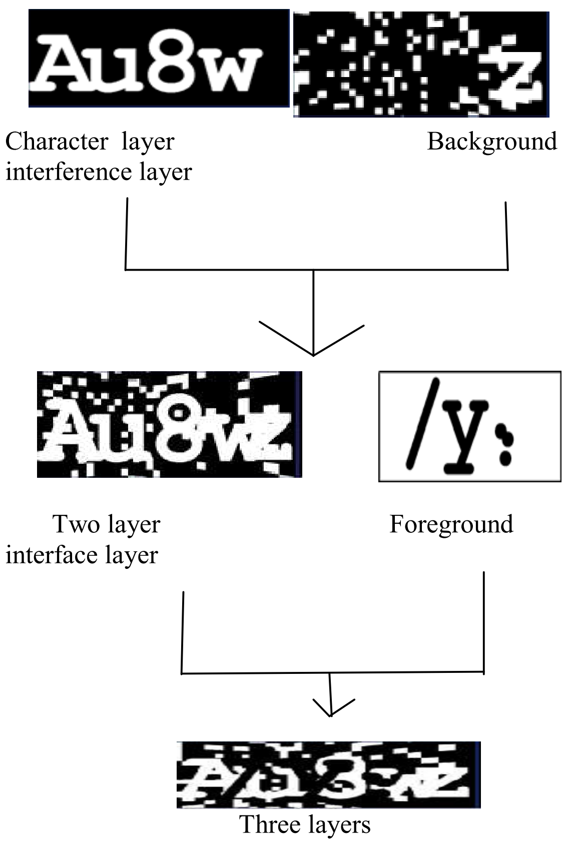


Fig 3. Diagram of 3-layer model

The implementation of 3-layer dynamic CAPTCHA is very simple, as described in detail below: Note: The following steps (1) - (4) involve the character layer, while step (5) - (6) involve the background interference layer and the foreground interference layer, respectively.

(1) Determination of the number of characters. CAPTCHA often consists of 4-7 characters, and we choose the minimum length 4. (2) Random selection of characters. Our program randomly chooses 4 characters from a total of 62 characters consisting of 26 lowercase letters, 26 uppercase letters and 10 Arabic numerals. (3) Determination of character attributes. Optional character attributes are size, font, color, tilt, twist, spin, etc. In the same CAPTCHA, a variety of fonts or different sizes can easily increase the difficulty of attack. Colors of diversity, tilt, twist and spin could also greatly improve security. In this case we set font type as Courier New, and size 40 pixels. In order to reduce the ultimate gif size for fast network transmission, we use only 2 colors: black and white, and set identifying characters white. (4) Determination of character positions. As it is known, various smooth curves in mathematics, such as the sine curve, cosine curve, tangent curve, cotangent curve and logarithmic curve, etc, can not only produce good visual effects, but also bring great challenges for computer programs to break, considering the non-linear characteristic of these curves. (5) Implementation of the background interference layer. The background interference of this design can include not only background color transformation and messy pixels or characters, etc, traditional interference sources used in 2Dstatic images, but also light, smoke and texture rendering, etc, new interference sources used in 3D dynamic videos. In this case, we combine the interference point and the interference character, randomly selecting some regions and generating a lot of interference points as well as an interference character. (6) Implementation of the foreground interference layer. Different with the background interference layer, the foreground interference is to make the identifying characters in the character layer incomplete, further increasing difficulty of attack whether using single frame or multiple frames. foreground interference involves character interference, line interference and point interference. In this case we combine all three together.

Conclusion

In this article, we proposal a novel, practical and safe 3-layer dynamic CAPTCHA, originally bonding the biological vision theory with the single-frame zero-knowledge theory, ensuring it not only extremely hard to recognize every single frame, but easy to identify for humans as well. It also makes full use of disadvantages of computers in recognizing numerous moving objects from a complicated background, making it still very difficult for computer programs to break even using several frames. Moreover, the 3-layer structure makes the design of CAPTCHA more distinct, taking on high expansibility as well as plenty of room for sustainable optimization. The security analysis shows that this new design can prevent attacks efficiently from existing algorithms as well as possible ones using multiple frames. Furthermore, transformation from 2D to 3D optimizes the visual effects, providing a new idea for the design of CAPTCHA. In short, this article will be a good guide for the design of next generation CAPTCHA, and that how to design a more practical and safer 3-layer dynamic CAPTCHA will be the focus of our further research.

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