3DOC: 3D Object CAPTCHA

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ABSTRACT
Current 2D CAPTCHA mechanisms can be easily defeated by character recognition and segmentation attacks by automated machines [1]. Recently, 3D CAPTCHA schemes [2] have been proposed to overcome the weaknesses of 2D CAPTCHA for a few websites. However, [4] demonstrates the offline pre-processing techniques to break 3D CAPTCHA as well. In this work, we propose a novel 3D object based CAPTCHA scheme that projects the CAPTCHA image over a 3D object. We develop the prototype and present the proof-of-concept of 3D object based CAPTCHA scheme to protect websites against automated attacks.

Categories and Subject Descriptors
K.6.5 [**Management of Computing and Information Systems**]: Security and Protection—*Authentication*; K.4.4 [**Computers & Society**]: Electronic Commerce—*Security*

General Terms
Security, Design, Experimentation, Human Factors

Keywords
Security, Authentication, CAPTCHA, 3D models

1. INTRODUCTION
The Completely Automated Public Turing test to tell Computers and Humans Apart (CAPTCHA) is a type of challenge and response test to distinguish humans and machines. CAPTCHA is widely used as a first line of defense to filter out automated attempts to access specific websites and deplete computing resources. However, 2D CAPTCHA is known to be vulnerable and even easily breakable by Optical Character Recognition (OCR) software, brute-force attack, or human CAPTCHA solvers, hired by attackers or spammers. In order to improve the weakness of 2D CAPTCHA, 3D CAPTCHA [2] has been proposed to present CAPTCHA or object in 3D for a challenge question, which makes it even harder for OCR software. 3D CAPTCHA explores the human's 3D spatial cognition abilities to differentiate from a machine. However, recent work demonstrates an approach to break 3D text CAPTCHA with a sequence of some offline processing techniques as described in [4]. They claimed that they could decode the 3D text CAPTCHA with 92% accuracy. In addition to 3D text CAPTCHA, a CAPTCHA based on 3D models has been proposed in [6], where several distorted 2D images are drawn from a 3D model and presented to users to correctly identify the image. Also, Sketcha[3] was proposed for the user to rotate several images until it is upright, where each image is automatically rendered from a 3D model using a randomized view point. However, Sketcha does not utilize the text information, relying only on images and a simple upright rotation puzzle.

WWW'14 Companion, April 7–11, 2014, Seoul, Korea.
ACM 978-1-4503-2745-9/14/04.
http://dx.doi.org/10.1145/2567948.2577300

2. OUR APPROACH
In this work, we explore a novel 3D object based CAPTCHA system, which essentially combines the benefits of 3D text CAPTCHA and Sketcha to make the CAPTCHA system more secure, robust, and less vulnerable. In particular, our approach first asks a user to solve the 3D object rotation problem, similar to Sketcha. Then, a user has to solve the 3D text CAPTCHA. We believe that 3D object rotation, as well as 3D text recognition, is difficult tasks for a simple machine to accurately solve.

The key concept in our work is quite simple. First, we randomly generate a 2D CAPTCHA image and a 3D object. Then, we apply the projective texture mapping which enables a textured image to be projected onto a scene. In our case, a textured image is CAPTCHA text, and a scene is a 3D object as shown below:

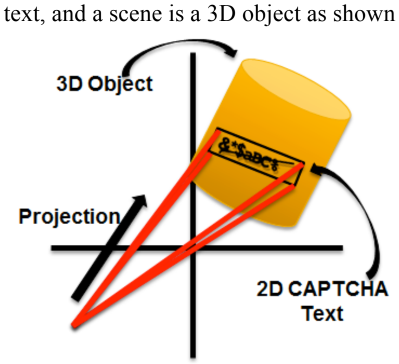

Figure 1. Projective CAPTCHA Image Texture Mapping

In particular, the projective texture mapping involves the following:

1. A model view transform to orient the projection in the scene.
2. A projective transform (perspective or orthogonal).
3. A scale and bias to map the near clipping plane to texture coordinates.

The main benefit of employing projective texture mapping is that it provides the random viewpoint as if by a slide projector, allowing us to easily randomize and control the initial 3D object and CAPTCHA texture. Our proposed system has several different components, as shown in Fig. 2. We randomly generate a text CAPTCHA from a conventional 2D CAPTCHA system. A 3D object model is randomly drawn from the pool of available 3D object sources. Then, we apply the projective texture mapping to project the 2D CAPTCHA image over the 3D object scene. After that, we randomize the viewpoint. The final 3D object CAPTCHA is presented to users and answers are validated. We developed the prototype to demonstrate the proof-of-concept of our approach using OpenGL, which provides rich 3D rendering libraries and enables us to easily create 3D objects. We further compare our approach with a 2D CAPTCHA system to determine the effectiveness of our scheme.

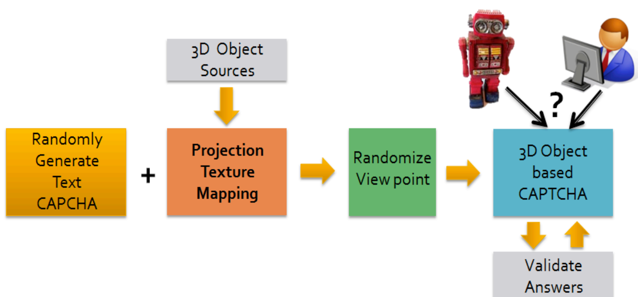

Figure 2. Overall proposed system architecture

3. EVALUATION

We implemented five different 3D objects and projected a CAPTCHA image into a 3D object. Fig. 3 illustrates the examples of 3D objects to be presented to the end users, where the 2D CAPTCHA 'USC' image is projected to different 3D object models. As we can see, initially the user has to rotate the 3D object to the correct position in order to observe the text CAPTCHA, as shown in Fig 4. The rotation task is not easily achievable by a machine, as it has to first determine the 3D object shape and the location of the CAPTCHA. On the other hand, humans can fairly quickly and easily perform the rotation task to identify the CAPTCHA in a few steps. Once rotation is completed, a user has to identify the given CAPTCHA. Since we project the CAPTCHA image onto different locations of the 3D object, some could be a bit easier to solve than others. We have tried projecting CAPTCHA image onto different locations at the given 3D object. In addition, we compared the 2D text CAPTCHA with our approach. We employed the OCR software from [5] to test whether commercial OCR can detect text in our approach. We validated that our proposed scheme is not breakable by OCR.

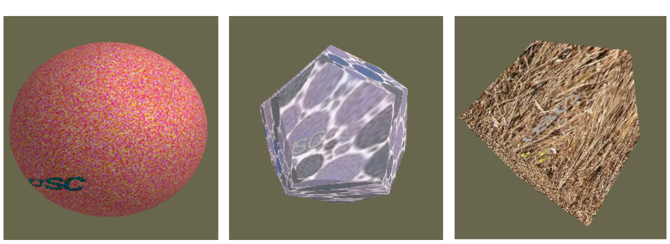

Figure 3. Examples of 3D Object with CAPCHA image 'USC'

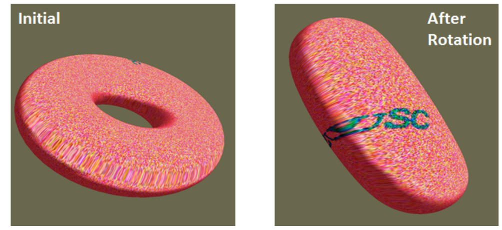

Figure 4. After Rotation task

4. CONCLUSION

Not only the proposed 3D object based CAPTCHA is simple but also it provides an elegant, powerful, and practical mechanism to differentiate a human from a machine by simultaneously presenting rotation tasks and CAPTCHA image, which are relatively easy for a human but harder for a machine to perform. The proposed work is still in the early prototype stage. However, the initial evaluation results demonstrate the effectiveness and feasibility of the proposed scheme for a next generation CAPTCHA system.

5. FUTURE WORK

We plan to explore further the noise, surface, and texture models over 3D CAPTCHA so that we can effectively distort the texture and image in a way that human can easily recognize but difficult for a machine to segment and recognize. Also, we plan to perform more extensive evaluations on our system with human and automated approaches that use vision and text recognition algorithms. We are interested in whether state of the art vision and text recognition mechanisms can break our CAPTCHA system.

6. ACKNOWLEDGMENT

The authors would like to thank Andrew Ling and Professor Ulrich Neumann at the University of Southern California for providing initial feedback on this work, and providing other helpful comments to improve this work.

7. REFERENCES

[1] Mori, Greg, and Jitendra Malik. "Recognizing objects in adversarial clutter: Breaking a visual CAPTCHA." *Computer Vision and Pattern Recognition, 2003. Proceedings. 2003 IEEE Computer Society Conference on*. Vol. 1. IEEE, 2003.

[2] Imsamai, Montree, and Suphakant Phimoltares. "3D CAPTCHA: A next generation of the CAPTCHA." *Information Science and Applications (ICISA), 2010 International Conference on*. IEEE, 2010.

[3] Ross, Steven A., J. Alex Halderman, and Adam Finkelstein. "Sketcha: a CAPTCHA based on Line Drawings of 3D Models." *Proceedings of the 19th international conference on World wide web*. ACM, 2010.

[4] Nguyen, Vu Duc, Yang-Wai Chow, and Willy Susilo. "Breaking a 3D-based CAPTCHA scheme." *Information Security and Cryptology-ICISC 2011*. Springer Berlin Heidelberg, 2012. 391-405.

[5] ABBYY OCR Software, http://www.abbyy.com

[6] Yan, J. and El Ahmad A.S, "Usability of CAPTCHAs or usability issues in CAPTCHA design.: Proc. Of 4th symposium on Usable Privacy and Security, ACM, 2008