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Telling Computers and Humans Apart Automatically Using Activity Recognition

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***Abstract*— This paper proposes a new image based CAPTCHA test, Activity Recognition CAPTCHA. In this test the user is presented with a set of distorted images depicting a randomly chosen activity. The user has to recognize the common activity associated with the images and annotate it from a given list of activities to pass the test. The user studies indicate that this CAPTCHA can be solved with 99.04% average pass rate while that of ESP PIX CAPTCHA is 85.44% and SQUIGL PIX is 67.84%. Average time taken to pass the test is less than 10 seconds.**

***Keywords*— CAPTCHA, security, reverse turing test, Activity recognition.**

I. INTRODUCTION

Internet is becoming an integral part of our everyday life. Web services designed to be used by humans are abused by automated computer programs called bots that pose as humans and perform malicious activities. CAPTCHA, Completely Automated public Turing test to tell Computers and Humans Apart, is a test administrated by a computer to differentiate humans and bots in an online environment. It can be defined [1]-[3] as a program that can generate and grade test which most humans can pass but difficult for automated computer programs to pass. By including CAPTCHA as a part of registration process it is comparatively easy for a computer to decide whether it is interacting with a human or another automated computer program.

II. RELATED WORK

Since its introduction in 2001 by Luis von Ahn, Manuel Blum and John Langford of Carnegie Mellon University, many design variations has appeared for CAPTCHA. Most of them are text based. Commercial web sites use text based CAPTCHAs because of their simplicity, ease of design and implementation. Some of the text based CAPTCHAs are EZ-Gimpy, Gimpy, Gimpy R, Pessimal print, reCAPTCHA etc. (Figure.1). Ez-gimpy requires the user to type in an English word picked from dictionary that is made noisy and distorted before being presented to the user. Gimpy-r is a variant of Ez-Gimpy in which instead of meaningful words random character strings are used. Gimpy is made more difficult by requiring the user to identify three different words out of seven or ten words presented in a cluttered, overlapped, and distorted manner. In reCAPTCHA [1] user is presented with two or three images of words from scanned texts; one word being recognized by OCR systems and the other unrecognized. The user has to type in the two words to pass the text. Even though text based CAPTCHAs are popular, the problem is that most of them has been broken using object recognition techniques [4], with an accuracy of 93% on EZ-gimpy, 78% on Gimpy R and 34% on Gimpy. This reduces the reliability of text based CAPTCHAS. The test can be made harder to break by adding noise and distortion, but that often makes them harder for humans also to understand.

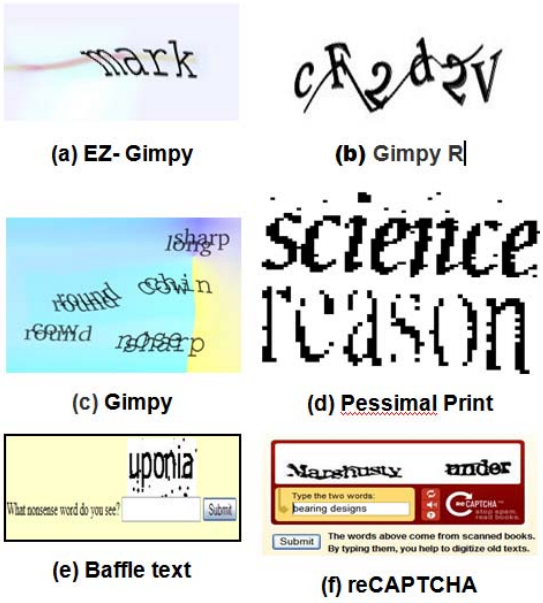

Figure.1 Text based CAPTCHAs

An alternative is to use image based CAPTCHAs. These types of CAPTCHAs usually present the user with the image of an object and request the user to annotate it. But this may sometimes lead to misspelling, synonymy and polysemy [5]. Another drawback is that some images of objects used may not be familiar to users of different countries. PIX, ESP PIX, SQUIGL PIX [1], and IMAGINATION [13, 14] are some of the image based CAPTCHAs (Figure.2).

PIX and ESP PIX present the user with images of objects for annotation. In SQUIGL PIX, the users are to trace the required object in the image to pass the test.

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IMAGINATION presents the user with a two step challenge. In the first step the user is required to click near the geometric centre of a sub-image presented as part of a composite image. If he succeeds another image is presented which is to be annotated to pass the test. In our study with 25 subjects in the age of 20-35, who are very much familiar with using computers and Internet, most of them showed difficulty in finding the centre of the sub-image. Some of them were even temporarily banned from the site [13] for making too many false attempts.

Figure 2. Image based CAPTCHAs

Another variant of image based CAPTCHA is Microsoft Asirra [6]. Here the users are required to type in the number of images depicting cats from a set of 12 images consisting of cats and dogs. Even though it is a simple test, the reliability of it has been questioned by Philippe Golle in [7].

III. THE PROPOSED CAPTCHA TEST

The proposed test, Activity Recognition CAPTCHA (Fig.3) is an image based CAPTCHA. It is based on the fact that humans are better than computers at understanding the semantic meaning of images. Given an image depicting an activity, human can easily identify it even if the image is distorted to certain extend. Though a lot of work has been done in the area of machine vision, activity recognition is still a tough task for machines.

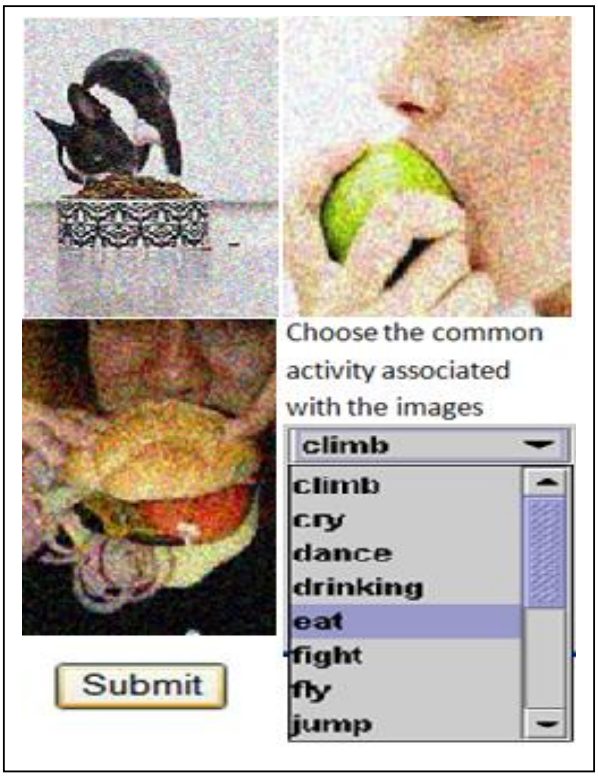

Figure3. Activity Recognition CAPTCHA

In Activity Recognition CAPTCHA, the user is presented with three distorted images depicting a common activity R. The activity is selected randomly and the image database is searched for that particular activity. Three random images matching R is selected. These images are distorted with distortion parameter D, chosen such a way that the distorted outputs maintain visible clarity to humans while making automated recognition difficult. The three distorted images are then scaled and presented to the user to annotate. In-order to avoid the problem of misspelling, the user is provided with a list of activities from which he can choose the common activity associated with the images.

A. Algorithm

The algorithm for the proposed CAPTCHA test is briefed below:

1. Choose a random activity R from a set of activities.
2. Select three random images {I1, I2, I3} depicting activity R from the image database.
3. Distort the images with distortion parameter D chosen at random.
4. Apply scaling to all images to produce equally sized images and present it to user for annotation.
5. If the user chooses the correct activity R, proceed to the next stage else go to step1 and present another test.

B. User studies and results

Our image based CAPTCHA test makes use of the hard machine vision problem of recognizing activity depicted in images to distinguish between humans and automated computer programs, a task that is comparatively easy for humans. The test images were taken from Google images [15]. The images were resized and slightly distorted before presenting to the user. To quantitatively evaluate Activity Recognition CAPTCHA, we performed user studies among 25 subjects in the age range of 25-35, all familiar with computers and using Internet. We have compared the performance of Activity recognition CAPTCHA with other similar image based CAPTCHAs such as ESP PIX and SQUIGL PIX. Each user is given 25 tests of all the three CAPTCHAs. The user study results for the three CAPTCHAs are briefed in Table 1.

TABLE I. COMPARATIVE STUDY

	CAPTCHA test		
	ESP PIX	***SQUIGL PIX***	***Activity Recognition CAPTCHA***
Average time in seconds to pass the CAPTCHA test	10.42	12.56	6.03
Average success rate (for 25 tests)	85.44%	67.84%	99.04%

Fig.4 and Fig.5 shows the detailed results of user studies for the three types of CAPTCHAs. The following observations are made:

- Average time taken to pass Activity Recognition CAPTCHA is found to be almost 50% less compared to that of ESP PIX and SQUIGL PIX.
- Average success rate of Activity Recognition CAPTCHA is 99.04%, ESP PIX is 85.44% and SQUIGL PIX is 67.84%.
- The user response time is found to be more consistent in Activity Recognition CAPTCHA than the other two CAPTCHAs.
- Out of 25 users, 21 users passed all the 25 tests of Activity Recognition CAPTCHA given to them.

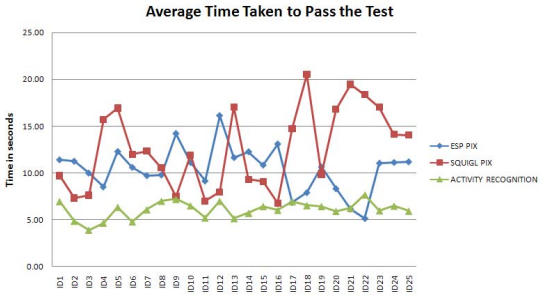

Figure 4. Average time taken to pass CAPTCHA test

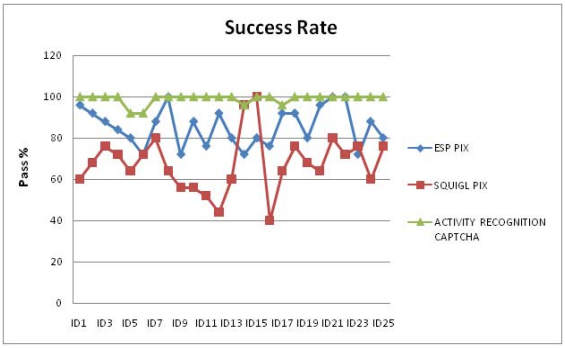

Figure 5. Success rate

C. Discussion

We have presented Activity Recognition CAPTCHA, a simple user friendly image based CAPTCHA test. Some features of the test are listed below:

- Activity recognition has the property of being universal. For example if "Read" is the activity chosen, users will be able to recognize the activity as "Read" irrespective of the country in which they live in. But in the case of some of the image based CAPTCHAs in which users are required to annotate the image of the object presented to them, some of the objects may not be familiar to users of different countries. For example, the image of the bird Kiwi may be familiar to people in New Zealand but may not be familiar to people in India.
- No problems like misspelling, synonymy, or polysemy since the user is not required to type in anything for validating the test.
- Unlike some of the text and image based CAPTCHAs, the user need not be familiar with difficult English words to pass the test.
- For attacking the CAPTCHA, the automated programs should either identify the activity shown in the images, which is a hard machine vision problem, or the database has to be attacked. Even doing so may not guarantee success since the images are distorted before presenting to the user. Because of this automated

programs cannot get the activity label simply by comparing the image with that in the database [2, 3].

- Database of well annotated images describing different activities has to be maintained for this test. Keeping a dynamic database will make the test more robust.
- As the proposed test is an image based CAPTCHA; it is not suitable for visually impaired users. Also it may be challenging for users with learning disabilities who may not be able to recognize the activity depicted in the images.

V. CONCLUSION

In this paper, we have presented a user friendly, GUI based Activity Recognition CAPTCHA, a simple image based CAPTCHA test that exploits a hard machine vision problem of recognizing activity depicted in images, which is easy for humans to solve. The average time taken to pass the test is less than 10s, which is a desirable property of CAPTCHA. The ease of use and universality makes it desirable over other similar image based CAPTCHAs.

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