Design of a Human Interaction Proof (HIP) using Human Cognition in Contextual Natural Conversation

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***Abstract*—Nowadays, many services in the internet including Email, search engine, social networking are provided with free of charge due to enormous growth of web users. With the expansion of Web services, denial of service (DoS) attacks by malicious automated programs (e.g., web bots) is becoming a serious problem of web service accounts. A HIP, or Human Interactive Proofs, is a human authentication mechanism that generates and grades tests to determine whether the user is a human or a malicious computer program. Unfortunately, the existing HIPs tried to maximize the difficulty for automated programs to pass tests by increasing distortion or noise. Consequently, it has also become difficult for potential users too. So there is a tradeoff between the usability and robustness in designing HIP tests. In our proposed technique we tried to balance the readability and security by adding contextual information in the form of natural conversation without reducing the distortion and noise. In the result section, a microscopic large-scale user study was conducted involving 110 users to investigate the actual user views compare to existing state of the art CAPTCHA systems like Google's reCAPTCHA and Microsoft's CAPTCHA in terms of usability and security and found our system capable of deploying largely over internet.**

Keywords— Cognitive Psychology; CAPTCHA; HIPs; Usability ; OCR; Web Services; Context; Conversation.

I. INTRODUCTION

CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart) or HIP (Human Interactive Proof) is an automatic security mechanism used to determine whether the user is a human or a malicious computer program .It is a program that generates and grades tests that are human solvable, but intends to be beyond the capabilities of current computer programs [1]. It has become the most widely used standard security technology to prevent automated computer program attacks. With the expansion of Web services, denial of service (DoS) attacks by malicious automated programs (e.g., bots) are becoming a serious problem as masses of Web service accounts are being illicitly obtained, bulk spam e-mails are being sent, and mass spam blogs (splogs) are being created. Thus, the Turing test is becoming a necessary technique to discriminate humans from malicious automated programs [1].

In the original Turing Test, a human judge was allowed to ask a series of questions to two players, one of which was a computer and the other a human. Both players pretended to be human, and the judge had to distinguish between them [2]. CAPTCHAs are similar to Turing Test in that they distinguish humans from computers, but they differ in that the judge is now a computer.

The CAPTCHA is usually a simple visual test or puzzle that a human can complete without much difficulty, but an automated program cannot understand. The test usually consists of letters, numbers or their combination with overlapping and intersection. A typical example of a text based CAPTCHA challenge is shown in Figure 1. The CAPTCHA images may be distorted in some way or shown against an intricate background to keep them from being easily read by Optical Character Recognition (OCR) software) or other image recognition systems.

Currently, in order to defend malicious programs from issuing advertisements or other useless information recklessly, message boards of BBS, blog and wiki have widely used CAPTCHA challenges as a defense mechanism [1],requiring that users must input the correct letters to leave a message. CAPTCHs have a wide variety of applications on the web such as:

Worms and Spam: CAPTCHAs also offer a plausible solution against email worms and spam: only accept an email if you know there is a human behind the other computer.

Web crawler: CAPTCHA provides reasonable solution, when one wants that web pages should not be crawled for indexing by search engines.

Online Polls: In November 1999, http://www.slashdot.com released an online poll asking for the best graduate school in computer science. IP addresses of voters were recorded in order to prevent single users from voting more than once. However, students at Carnegie Mellon figured out a way to stuff the ballots using programs that voted for CMU thousands of times. CMU's score started growing rapidly. The next day, students at MIT wrote their own voting program and the poll became a contest between voting "bots". But captchas offer a solution: voters should show they are human before being allowed to vote.

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Free Email Services: Several companies (Google, Yahoo!, Microsoft, etc.) offer free email services. Unfortunately –Web bots" which is a script capable of registering for thousands of email accounts every minute, wasting precious web space. This situation has been improved by requiring users to prove they are human before they can get a free email account.

Preventing Dictionary Attacks: Pinkas and Sander [3] have suggested using CAPTCHAs to prevent dictionary attacks in password systems

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.

Moreover, some spammers have found a creative way to provide their bots with CAPTCHA solving capabilities using pornographic sites – outsource the CAPTCHA-solving task to humans. For example, when a bot is faced with a CAPTCHA, it might place that CAPTCHA onto the entrance page of a pornographic site [12], and the next visitor to that site solves the CAPTCHA for the bot, in exchange for (free or price-reduced) entrance to the porn site[12].

Researches on CAPTCHA mechanism have gained significant attention recently. Researchers encourage images, audio and video as a possible alternative to text-based CAPTCHA [22, 5, 6, 7]. These tests are easier for humans to solve and tough for automated bots. Unfortunately, the existing CAPTCHA techniques tried to maximize the difficulty for automated programs to pass tests by increasing distortion or noise. Consequently, it has also become difficult for humans too. A recent study which investigated user's perceptions towards CAPTCHA challenges and also highlights the necessity for user friendly CAPTCHA challenges [8]. Results have shown that even experienced users face difficulties in solving a CAPTCHA challenge [8] need few tries or solving time is more than 15 seconds.

In this context, the work presented in this paper constitutes an effort towards focusing mainly on user's cognitive styles and performance related to CAPTCHA challenges within Web-based environments. Cognitive styles represent an individually preferred and habitual approach to organizing and representing information [9]. Various research attempts have been reported [10, 11] that investigate the effect of cognitive styles of users on preference and performance issues in Web-based environments. We tried to balance the readability and security by adding contextual information in the form of natural conversation without reducing the distortion and noise.

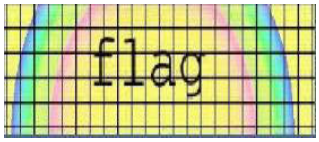
II. VARIOUS TYPES OF CAPTCHA METHODS

CAPTCHA methods, especially text-based, have been widely use as the main defense mechanism against bots on the web. Recently, with the advancements in computer vision technology, text-based systems have become vulnerable to bot attacks with a high success rate [13, 14, 15, 16, 17, 18]. Hence a lot of work has proposed alternate CAPTCHA systems such as image-based [19, 20, 21, 24, 25, 26] and audio-based systems [41, 28, 29, 30].

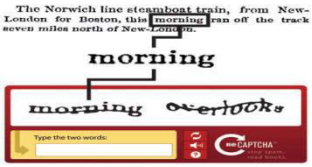
A. Text-Based CAPTCHAs:

In this system computer generates a sequence of letters or digits after distorting them with a certain amount of noise render them on to the screen. The user is asked to identify the characters in order to pass the test. GIMPY [31] is a very reliable text CAPTCHA built by CMU in collaboration with Yahoo to protect chat rooms from spammers who were posting classified ads and writing scripts to generate free e-mail addresses. Gimpy works by choosing ten words randomly from a dictionary, and displaying them in a distorted and overlapped manner (shown in fig. 1(a)). Ez–Gimpy [14] is a simplified version of the Gimpy CAPTCHA, adopted by Yahoo in their signup page. Ez-Gimpy requires the user to type in an English word picked randomly from dictionary (shown in fig. 1(b)). Another interesting character labeling based CAPTCHA is reCAPTHCA [35]. It is a free CAPTCHA service that helps to digitize books, newspapers and old time radio shows. More specifically, each word that cannot be read correctly by OCR is placed on an image and used as a CAPTCHA (in fig. 1(c)). Microsoft uses a different CAPTCHA for services provided under MS Numbrella. They use eight characters (upper case) and digits. Microsoft's CAPTCHA [34] is used for services including Hotmail, MSN and Windows Live as shown in Fig. 1(d) *foreground* is dark blue, and background is grey. Warping is used to distort the characters, which makes computer recognition very difficult.

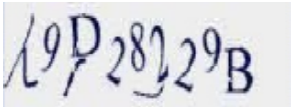
(a) GIMPY



(b) Ez–Gimpy



(c) reCAPTHCA



(d) Microsoft's CAPTCHA

(e) Google CAPTCHA

(f) Baffle Text

Fig. 1. Examples of text-based CAPTCHAs

Google [36] uses the CAPTCHA in many places. It is shown when URLs are added to Google and a new Gmail account is signed up (in fig. 1(e)). It is obvious that Google does not add background to the image. Baffle Text [33] is Xerox PARC's version of the Gimpy test .This doesn't contain dictionary words, but it picks up random alphabets to create a nonsense but pronounceable distorted text to defeat dictionary attacks (in fig. 1(f)). This technique overcomes the drawback of Gimpy CAPTCHA because, Gimpy uses dictionary words and hence, clever bots could be designed to check the dictionary for the matching word by brute-force.

Attacks on text-based systems mostly make use of OCR (optical character recognition) algorithms. These algorithms first segment the images into small blocks containing only one letter, and use pattern recognition algorithms to classify the letters in each block [13, 14, 15]. In counter-attack to these segmentation algorithms, text-based CAPTCHA systems employ the following techniques to increase robustness [37, 17]:

1. Adding more noises in the form of scattered lines and dots to the background.
2. Characters are connected, overlapped or twisted to increase difficulty in character recognition.

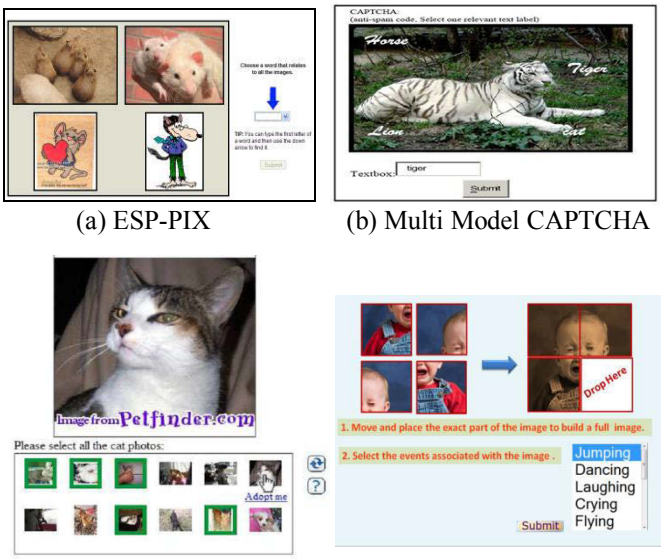
However, all the above techniques make the task harder for humans too. Connecting characters together creates ambiguous characters such as "vv" can be similar to "w", "cl" can be similar to "d", "nn" can be "m", "rn" can be "m" "rm" can be "nn" where users cannot be sure what they are. Moreover hard to tell distorted O from 0, 6 from G and b, 5 from S/s, 2 from Z/z, 1 from l. In case of dictionary words non-English users get into trouble with predicting.

B. Image-Based CAPTCHAs:

In this, user is required to identify image. The advantage of image based CAPTCHA over text based is that pattern recognition is a hard AI Problem and therefore it is difficult to break this test using pattern recognition technique. The users of this CAPTCHA usually interact using a pointing device, e.g., mouse. In general, image-based CAPTCHAs require larger web page area, and need an image database maintained at the server. ESP-PIX[20] is a Captcha script that instead of asking you to type letters requires that you look at a set of pictures and then select the word that best describes all the images(in fig. 2(a)). It is available in English therefore end user must have a comprehensive English vocabulary. There are only 27% people in the world are English speaking [6].

Asirra [19] a CAPTCHA that asks users to identify cats out of a set of 12 photographs of both cats and dogs provided by Petfinder.com are shown in fig. 2(c).Asirra is easy for users; user studies indicate it can be solved by humans 99.6% of the time in fewer than 30 seconds [21]. A typical Asirra challenge requires more screen space than a traditional text-based CAPTCHA. Moreover, Asirra is not accessible to those with visual impairments.

Multi Model CAPTCHA uses text and image based system together where end user is shown an image where four text labels associated with it. Text labels are attached in the image and the user is asked to select an appropriate text label [4]. A snapshot of Multi Model CAPTCHA is shown in fig. 2(b).



(a) ESP-PIX (b) Multi Model CAPTCHA

(c) Asirra CAPTCHA (d) Move & Select

Fig. 2. Examples of image-based CAPTCHAs

Move & Select [45] it's a 2 layer CAPTCHA, desired to improve security and reduce the solving time of human. In the proposed solution, we try to make use of human cognitive processing abilities into our CAPTCHA design (in fig. 2(d)). It is not suitable for visually impaired users. Also it may be challenging for users with learning disabilities. Table I summarizes all the image based CAPTCHAs discussed above.

C. Audio-Based CAPTCHAs:

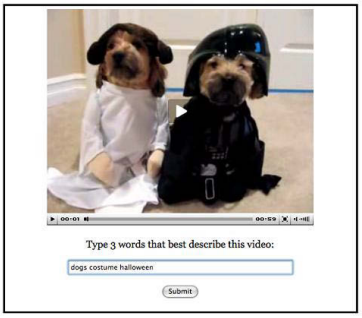
The program [41] picks a word or a sequence of numbers at random, renders the word or the numbers into a downloadable audio file and background noises are added to the sound clip using TTS software to make the test more robust against bots. It then presents the distorted sound clip to the user and asks users to enter its contents. These systems are highly dependent on the audio hardware and need to install essential software like Adobe Flash on their computers. These barriers lead to spend user's time more than standard response time which is typically about 5-15 seconds [40]. Because of high level of distortion characters produce similar sound like "d and b" [39]. These English words are unfamiliar to non-English humans. It helps visually disabled users but the worst case is for people who have problem in both hearing and vision. Fig. 3(b) below is the Google's audio enabled CAPTCHA.

Scheme	No of Choices	English Dependency	Probability of entering a Bot	Average Solving Time(in seconds)	Interaction
Move & Select	4	Yes	1/40	6.02	Mouse
ESP-PIX	72	Yes	1/72	13	Mouse
Asirra	12	no	1/12	17	Mouse
MMC	4	yes	1/4	8	Mouse & Keyboard

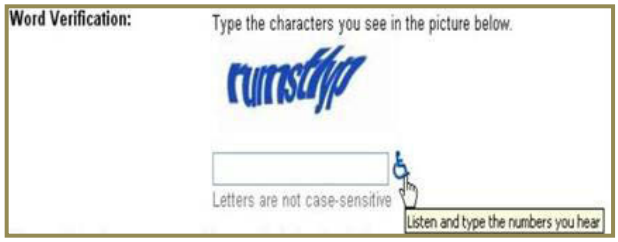
TABLE I: Summarization of the image based CAPTCHAs

D. Video-Based CAPTCHAs:

The final This is the newer CAPTCHA using animation or video in which a user must provide three words (tags) describing a video are shown in Fig. 3(a). According to some studies [42] [5], this approach may provide greater security (i.e., hard to be broken by computer programs) and better usability than text-based and image-based CAPTCHAs. YouTube which currently stores and indexes close to 150 million videos used as a video dataset in[44].However, video is also more complex and need more time and bandwidth to answer the challenge than other schemes.



(a) Video-based CAPTCHA



(b) Audio-based CAPTCHA

Fig. 3. Audio & Video based CAPTCHA

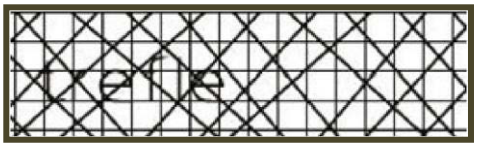
III. MOTIVATION

A. Tradeoff between usability and robustness

There are two major issues involved in designing a strong CAPTCHA test:

1. *Robustness* (difficult to break)
2. *Usability* (human friendly)

In the system *robustness*, the characters must be more distorted, so that the malicious computer software (e.g., a robot program) could not recognize them. *Usability* is concerned with making CAPTCHA tests easy to learn, use, understand and interpret. It has become difficult for automated programs to pass tests by increasing distortion or noise. Consequently, it has also become difficult for humans too example given in Fig. 4(a). That is not a good design obviously. On the contrary, if the design is quite easy to be identified by the user, then the computer may also be able to easily identify and solve it as illustrated in Fig. 4(b). We therefore need to adopt even more advanced human cognitive processing abilities to enhance CAPTCHA to overcome this problem.



(a) Better robustness but lack of usability

(b) Better usability but lack of robustness

Fig. 4. Usability vs. Robustness

So there is a tradeoff between the usability and robustness in designing CAPTCHA test. Moreover, it is also important to note that answering CAPTCHAs added annoyance for potential users, who feel difficult to prove that they are human. To our best survey, there has been no such a CAPTCHA that considered human cognitive processing abilities into the CAPTCHA design.

There are many types of CAPTCHA that have been increasingly created to solve previous problems in terms of reliability or usability. In this study, we believe that the reliability and usability of a CAPTCHA should be balanced. The ideal reliability and usability of a CAPTCHA would be present in the Fig. 5 .In order to have an ideal CAPTCHA, the usability features of a CAPTCHA should be considered as much as the reliability features are. The following parts are some literature review on applications of CAPTCHAs, different kinds of current CAPTCHAs and a survey of usability features.

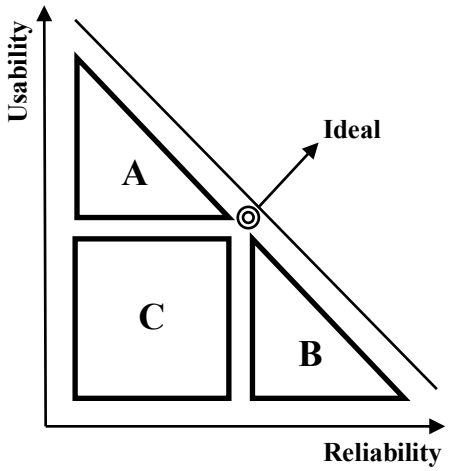


Fig. 5. Balancing Usability and Reliability

IV. THE PROPOSED CAPTCHA TEST

In this paper, the proposed method has been developed to distinguish human users and computer programs from each other by the fact that human user have special cognitive processing abilities on the other hand it is nearly impossible for OCR programs to have that and it falls into hard AI problem.

In designing a new CAPTCHA, the basic principles that we have taken care are:

1. Easy for most people to solve.
2. Difficult for automated bots to solve.
3. Easy to generate and evaluate.
4. Users do not feel bored.

Cognitive Psychology is the study of human perception, attention, memory and knowledge, and the ways in which these have been applied in the design of computer interfaces. Cognitive psychology[32] relates the use computer systems:

1. How humans perceive the world around them (e.g. Web Pages)
2. How they store and process information and solve Problems (e.g. CAPTCHA tests)
3. How they physically manipulate objects (e.g. clicking a link, button etc)

Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves[38].If a piece of information can be used to characterize the situation of a participant in an interaction, then that information is context.

In online we often engage ourselves in natural conversations by sending each other blog comments, chat messages, status updates and ‗tweets'. These messages are then indexed and made accessible through Internet search companies, instant messenger software or search index generators.

We know that there is a tradeoff between readability and security in solving CAPTCHA challenges. If we want to make the system more secure from the automated bots by adding more distortion and noise then the readability will be hampered. In our propose technique will try to balance the readability and security by adding contextual information in the form of natural conversation without reducing the distortion and noise.

In this paper we propose a human friendly CAPTCHA test, based on contextual conversation to secure web services as shown in Fig. 6. The test contains context information such as the knowledge in the form of natural language conversations.

In the server side, we need additional processing before presenting the CAPTCHA to the user. The required processing steps are discussed below.

1. Sample natural conversations (e.g. blog comments, chat messages, status updates and ‗tweets') are collected with the help of search index generators.
2. A meta conversation is collected from the sample.
3. The spell checking has been done using spell checker [27] to avoid spelling mistakes.
4. Using a parts of speech tagger [43] to identify the parts of speech in the meta dialogue and select the adjectives, adverbs and verbs as a candidate set for the distortion. This is necessary because exclusion of preposition (e.g. ‗of', ‗in', ‗to') and noun and pronouns are necessary, so we will only distort the adjectives, adverbs and verbs.
5. Then different degree of distortion (e.g. connected, overlapped, twisted and scaling etc) has been done to a randomly selected word from the candidate set.
6. Finally, fictitious characters are generated based on the meta conversation using only solid lines to avoid the bandwidth load on the network.

Fig. 6. Proposed contextual conversation CAPTCHA

In the client side, users are presented with an image like Fig. 6. and they are asked to type only the distorted characters from the conversation. If the distorted characters are presented without this contextual conversation then the user will have some difficulty in interpreting the characters but now it is relatively easy because the human has special cognitive processing abilities. Therefore the context presented along with the CAPTCHA has decreased the solving time and thus increased the readability and usability.

Other example of a natural conversation is the conversation between a father and his son. Here the context or the situation is –Ashfaq (son) has come to his father to tell his annual examination result". So the sample natural conversation between them is:

Son: –Papa, I have secured first position in the annual examination."

Father: –*Congratulation*! My boy I am so proud of you."

If the word *Congratulation* is highly distorted in the actual Captcha test, it is possible for the user to recover the word by perceiving the contextual conversation. Therefore reducing the solving time thus improves the usability without hampering the robustness.

V. USER STUDIES AND RESULTS

A large-scale user study was conducted to investigate the actual user views related to perceptions, cognition, and user preferences related to CAPTCHA systems with real usage scenario. An invitation was announced on the web site of the University and on social networking sites, by sending invitation to known email addresses in order to recruit participants for the survey. The aim of this selection process was to recruit a representative sample of participants of varying profiles, intended to increase internal validity of the survey by involving expert, average and novice users with respect to CAPTCHA challenges. For this purpose, we first built a website which would present the users with sample challenges.

In our experiment, we presented users first with as survey asking the following information:

1. Age
2. Native language (one from the Wikipedia list)
   (If native language is not English) Years studying English
3. Gender
4. Education (one of: no formal education, high school, bachelor's degree, master's degree, PhD)
5. Country of birth
6. Country of residence
7. Familiarity with computers (e.g. Internet, forum, blogs, and social networks)
8. Years using the internet
9. Frequency of internet use (daily, weekly, monthly or yearly)

Participant(ID)	Age (years)	Years of internet use	Frequency of internet use per day(hours)
ID 1	26	5	4-6 (hrs)
ID 3	18	3	9 (hrs)
ID 9	23	6	2-5 (hrs)
ID 14	37	12	6-7 (hrs)
ID 9	29	8	5 (hrs)
ID 23	14	1	2-3 (hrs)

TABLE II: listed some of the randomly selected participants or the users.

A. Demographics of Participants

A total of 110 people participated so far of age between 14 and 66 in the study between February and April 2012. 18 of them completed half of the test, due to internet disconnection or had double answers and were omitted from the test sample. The final sample included 92 valid participants which mean that they does not have any kind of vision problem that hampered their effort to identify colors, shapes, or patterns. The distribution in age groups is depicted in Table III.

	Gender		Age Ranges			
	Male	Female	14-19	20-32	33-49	50-66
N	66	26	18	39	26	09
%	71.7	28.3	19.6	42.4	28.2	9.8

Table III: Demographics of the sample

B. User Study Layout

The participants were asked to visit a Web-page in order to take part in the study.

1. An initial questionnaire asking the users to enter the information explained above (e.g. Age, Gender, Years using the internet, Frequency of internet use etc.)
2. A 1-page description of Contextual Conversation CAPTCHA, Microsoft's CAPTCHA and Google's re-CAPTCHA, showing users how to solve each challenge with pictorial description.
3. Then one challenge from each of the Contextual Conversation CAPTCHA, Microsoft's CAPTCHA and re-CAPTCHA.
4. A final short questionnaire asking users to rate Contextual Conversation CAPTCHA for ease of use as compared to and re-CAPTCHA.

	CAPTCHA test		
	Contextual Conversation CAPTCHA	**Google's re-CAPTCHA**	**Microsoft's CAPTCHA**
Average solving time in seconds	8.17	11.61	11.93

Table IV: Average Time taken per challenge for each of the systems (in seconds)

CAPTCHA test	**Outcome**		**Average Submit Time (*in seconds*)**	**Average Success Time (*in seconds*)**
	Success	***Failure***		
Contextual Conversation CAPTCHA	81/92 ≈88.04%	11/92 ≈11.96%	752/92 ≈ 8.17 s	752/81 ≈ 9.28 s
Google's re-CAPTCHA	85/92 ≈92.39%	7/92 ≈7.61%	1068/92 ≈ 11.61 s	1068/85 ≈ 12.56 s
Microsoft's CAPTCHA	77/92 ≈83.69%	15/92 ≈16.31%	1097/92 ≈ 11.93 s	1097/77 ≈ 14.24 s

Table V: Overview of the user result data

A detailed pictorial description of each of the CAPTCHA's was necessary for fair usage data and results. There may be some users seeing a CAPTCHA for the first time on the other hand it is necessary to introduce the participants with our Contextual Conversation CAPTCHA. The study took an average of 5.6 minutes to complete for each participant.

C. Usability Study

Quoted from Jakob Nielsen [22], usability is defined by the following five quality components:

- *Learnability:* How easy is it for users to accomplish basic tasks the first time they encounter the design?
- *Efficiency:* Once users have learned the design, how quickly can they perform tasks?
- *Memorability:* When users return to the design after a period of not using it, how easily can they re-establish proficiency?
- *Accuracy:* how successfully can a user pass a challenge? and how easily can they recover from the errors?
- *Satisfaction:* How pleasant is it to use the design?

Typically, the basic task that a CAPTCHA imposes to users is intuitive, easy to understand and easy to remember. Thus, CAPTCHA has a relatively good memorability. Therefore, in this paper, we will only consider the other four quality components.

1. *Average solving time*

As shown in Table IV, users complete text-based Contextual Conversation CAPTCHA challenges faster than that of Google's re-CAPTCHA and Microsoft's CAPTCHA. Each user takes an average of 3 seconds more to complete compare to Contextual Conversation CAPTCHA.

Average solving time in Contextual Conversation CAPTCHA is about 8.17 seconds from the distribution plots shown in fig 8(a) .On the other hand solving time is comparatively higher for Google's re-CAPTCHA with most of the users taking around 11.61 seconds and for Microsoft's CAPTCHA is 11.93 seconds (in fig 8(b),8(c)) So it has better efficiency compare to others.

2. *Accuracy*

Accuracy or the success rate is defined how successfully a participant can pass a CAPTCHA challenge .The total number of correct attempts of Contextual Conversation CAPTCHA (e.g. 88.04%) is higher than Microsoft's CAPTCHA(e.g. 83.69%) as shown in Table V, which clearly indicates that users are able to solve more challenges of Contextual Conversation CAPTCHA correctly .Fig 7 shows a graphical representation of the difference in success rates among 3 tests used in our evaluation which signifies the proposed CAPTCHA has a higher accuracy or success rate.

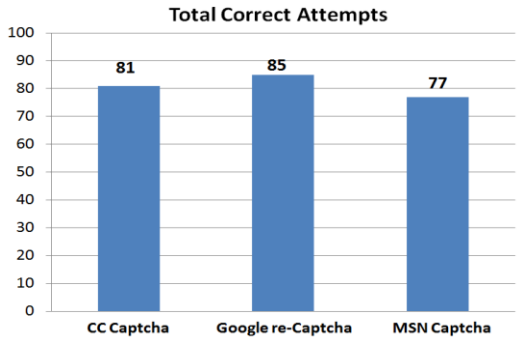
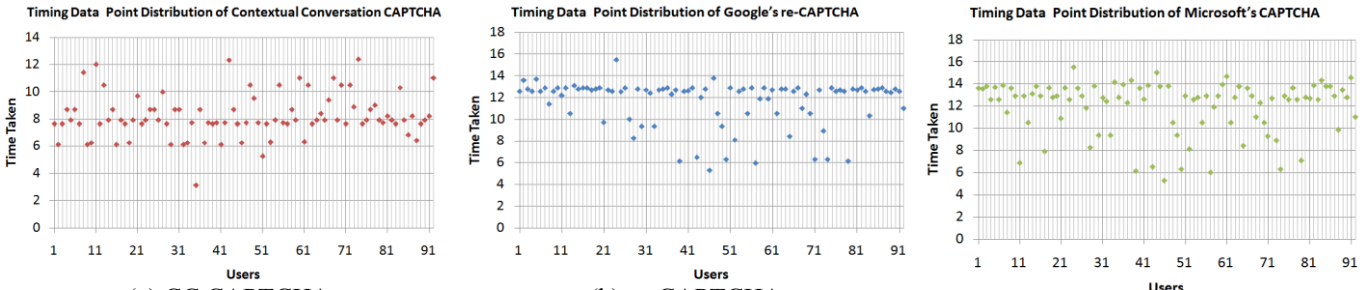


Fig. 7 .Total correct attempts out of 92 attempts



(a) CC CAPTCHA (b) re-CAPTCHA (c) MSN CAPTCHA

Fig. 8.Timing Distribution of each system for all users

We notice that the success rate of Contextual Conversation CAPTCHA (e.g. 88.04%) is very close to re-CAPTCHA (e.g. 92.39%). This is actually surprising. We expected that solving a Contextual Conversation CAPTCHA challenge will be much harder than solving a re-CAPTCHA challenge because text-based CAPTCHAs have been widely deployed for a long time and users are quite familiar whereas users were experiencing our system for the very first time. This clearly suggests that our proposed design is pretty learnable.

3. *Ease of use*

After the completion of the test users were asked to rate the system by answering a question as presented below to compare easiness level between Contextual Conversation CAPTCHA and re-CAPTCHA.A five-point Likert scale was used to rank the level of importance from "Not Important" (1) up to "Most Important" (5). So we have used that scale as below

- 1, if participants found re-CAPTCHA to be way easier.
- 3, if participants found re-CAPTCHA and Contextual Conversation CAPTCHA to be equal in case of Easiness.
- 5, if participants found Contextual Conversation CAPTCHA to be way easier.
- 2 or 4, if they were slightly inclined towards re-CAPTCHA or Contextual Conversation CAPTCHA, respectively.

Fig 8 shows the distribution for the easiness rating. About 65.22% of the users rated 4 and 5 indicating Contextual Conversation CAPTCHA is easier than re-CAPTCHA. Only 11.81% of the users rated 1 and 2 indicating re-CAPTCHA to be easier while 22.97% of the users rated 3 indicating they considered both systems to be equally easy. So we conclude that users subjectively satisfied and they will be willing to use such a scheme in future. So we have validated all the 5 usability goals defined by Jakob Nielsen with respect to our design. So our system successfully passed the usability test.

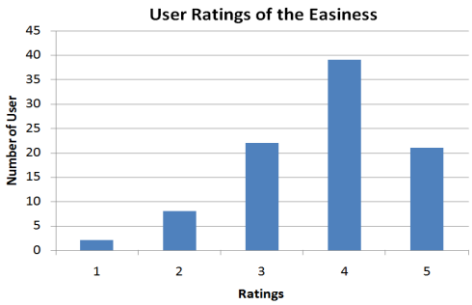


Fig. 8: We asked users to comparatively rate Contextual Conversation CAPTCHA and re-CAPTCHA on the metrics easiness. Rating 1,2 indicate re-CAPTCHA to be more easier, rating 3 indicate both systems are equal and rating 4,5 indicate Contextual Conversation CAPTCHA to be more easier.

VI. Conclusion and Future Works

In this paper, we design a HIP named contextual conversation CAPTCHA just to balance the readability and security of the CAPTCHA challenge design. By adding distortion and noise we restrict BOTs to break the test, but it eventually also difficult to humans to solve. We overcame this problem by adding contextual information in the form of natural conversation without reducing the distortion and noise. We have validated our test through microscopic large-scale user study and find that our test is capable of being deployed in the internet. Moreover, the proposed approach is not suitable for visually impaired users and it may be challenging for users with learning disabilities. Our test may create problems for users who are not that much comfortable with English. So, our future work will undergo with the design of a native language CAPTCHA with the help of Google translator to localize the test, then that will be more usable to the users.

References

[1] L. von Ahn, M. Blum, and J. Langford, "Telling humans and computers apart automatically," Communications of the ACM, vol. 47, no. 2, pp. 57-60, February 2004.

[2] M. Blum, L. A. von Ahn, and J. Langford, "The CAPTCHA Project, Completely Automatic Public Turing Test to Tell Computers and Humans Apart," Nov. 2000, http://www.captcha.net, Dept. of Computer Science, Carnegie-Mellon Univ.

[3] A. Turing. Computing machinery and intelligence. Mind, 49:433–460, 1950.

[4] Almazayd, A.S. Ahmed , Y Kouchay, ―Multi Modal CAPTCHA: A User Verification Scheme". Presented at Int Conf n Information Science and Application, Korea, 2011

[5] Kluever, K.A., and Zanibbi, R. Balancing Usability and Security in a Video CAPTCHA. In Proc. SOUPS 2009, ACM Press (2009), Article 14, 11 pages.

[6] English Language taken from wikipedia and available at http://www.en.wikipedia.com/English_Language.

[7] Golle, P. Machine Learning Attacks Against the Asirra CAPTCHA. In Proc. CCS 2008, ACM Press (2008), 535-542.

[8] Fidas, C., Voyiatzis, A., and Avouris, N. On the Necessity of User-friendly CAPTCHA. In Proc. CHI 2011, ACM Press (2011), 2623-2626.

[9] Riding, R.J., and Cheema, I. Cognitive styles - An Overview and Integration. Educational Psychology 11, 3/4 (1991), 193-215.

[10] Brusilovsky, P., Kobsa, A., and Nejdl, W. The Adaptive Web: Methods and Strategies of Web Personalization. Springer, Berlin, Heidelberg, 2007.

[11] Brown, E., Brailsford, T., Fisher, T., Moore, A., and Ashman, H. Reappraising Cognitive Styles in Adaptive Web Applications. In Proc. WWW 2006, ACM Press (2006), 327-335.

[12] Van Oorschot, P. C. and Stubblebine, S. 2006. On Countering Online Dictionary Attacks with Login Histories and Humans-in-the –loop. ACM Transaction on Information and System Security. 9.3.August 2006:235-258.

[13] J. Yan and A. S. El Ahmad. A low-cost attack on a microsoft captcha. In Proceedings of the 15th ACM conference on Computer and communications security, CCS '08, pages 543–554, New York, NY, USA, 2008. ACM.

[14] G. Mori and J. Malik. Recognizing objects in adversarial clutter—breaking a visual captcha. In Proceedings of the Conference on Computer Vision and Pattern Recognition, 2003

[15] K. Chellapilla and P. Simard. Using machine learning to break visual human interaction proofs (hips). In In Advances in Neural Information Processing Systems, pages 265–272, 2005.

[16] Breaking text captcha.
http://www.blackhat-seo.com/2008/how-to-break-captchas/.

[17] A. S. El Ahmad, J. Yan, and L. Marshall. The robustness of a new captcha. In Proceedings of the Third European Workshop on System Security, EUROSEC '10, pages 36–41, New York, NY, USA, 2010.ACM.

[18] E. Bursztein, S. Bethard, C. Fabry, D. Jurafsky, and J. C. Mitchell. How good are humans at solving captchas? a large scale evaluation. In Proceedings of 2010 IEEE Symposium on Security and Privacy(Oakland'10), 2010

[19] J. Elson, J. R. Doucerur, J. Howell, and J. Saul. Asirra: A Captcha that exploits interest aligned manual image categorization. In Proceedings of the 14th ACM conference on Computer and communications security, CCS '07, pages 366–374, New York, NY, USA, 2007. ACM.

[20] Esp-pix. http://server251.theory.cs.cmu.edu/cgi-bin/esp-pix/esp-pix.

[21] M. Chew and J. D. Tygar. Image recognition captchas. In Proceedings of the 7th International Information Security Conference (ISC), pages 268–279, 2004.

[22] Jakob Nielsen. Usability 101: Introduction to Usability, 2003. Available at http://www.useit.com/alertbox/20030825.html.

[23] R. Datta, J. Li, and J. Z.Wang. Imagination: a robust image-based captcha generation system. In Proceedings of the 13th annual ACM international conference on Multimedia, MULTIMEDIA '05, pages 331–334, New York, NY, USA, 2005. ACM

[24] Sq-pix. http://server251.theory.cs.cmu.edu/cgi-bin/sq-pix.

[25] P. Matthews and C. C. Zou. Scene tagging: image-based Captcha using image composition and object relationships. In Proceedings of the 5th ACM Symposium on Information, Computer and Communications Security, ASIACCS '10, pages 345–350, NewYork, NY, USA, 2010. ACM

[26] B. B. Zhu, J. Yan, Q. Li, C. Yang, J. Liu, N. Xu, M. Yi, and K. Cai. Attacks and design of image recognition captchas. In Proceedings of the 17th ACM conference on Computer and communications security, CCS '10, pages 187–200, New York, NY, USA, 2010. ACM

[27] http://www.spellchecker.net/spellcheck/

[28] J. P. Bigham and A. C. Cavender. Evaluating existing audio captchas and an interface optimized for non-visual use. international conference on Human factors in computing systems, CHI '09, pages 1829–1838, New York, NY, USA, 2009.ACM.

[29] Audio and visual captcha. http://www.nswardh.com/shout/.

[30] H. Gao, H. Liu, D. Yao, X. Liu, and U. Aickelin. An audio captcha to distinguish humans from computers. In Proceedings of the 2010 Third International Symposium on Electronic Commerce and Security, ISECS '10, pages 265–269, Washington, DC, USA, 2010. IEEE Computer Society.

[31] School of Computer Science. (2009, Dec.). Gimpy. Carnegie Mellon. [Online]. Available: http://www.captcha.net/captchas/gimpy/.

[32] http://en.wikipedia.org/wiki/Cognitive_psychology

[33] M. Chew and H.S. Baird, ―BaffleText, a Human Interaction Proof", In Proceedings of the 10th SPIE/IS&T Document Recognition and Retrieval Conference (DRR'03), Santa Clara, CA, USA, 2003, pp. 305-316.

[34] Hotmail, https://signup.live.com/signup.aspx.

[35] http://recaptcha.net/

[36] Google Accounts, https://www.google.com/accounts/NewAccount.

[37] K. Chellapilla, K. Larson, P. Simard, and M. Czerwinski. Designing human friendly human interaction proofs (hips). In Proceedings of the SIGCHI conference on Human factors in computing systems, CHI'05, pages 711–720, New York, NY, USA, 2005. ACM.

[38] Rodden, T., Cheverst, K., Davies, K. Dix, A.. Exploiting Context in HCI Design for Mobile Systems. Workshop on Human Computer Interaction with Mobile Devices (1998)

[39] Jeff Yan, Ahmad Salah El Ahamd. " Usability OF CAPTCHAs Or usability issues in CAPTCHA design"

[40] http://captcha-bypass.com/

[41] T.Y Chan. ―Using a Text-to-Speech Synthesizer to Generate a Reverse Turing Test", In Proceedings of the 15th IEEE International Conference on Tools with Artificial Intelligence, Sacramento, CA, USA, 2003, pp. 226-232.

[42] Cui, J.-S., Mei, J.-T., Wang, X., Zhang, D., Zhang, W.-Z.: A CAPTCHA Implementation Based on 3D Animation. In: International Conference on Multimedia Information Networking and Security, MINES, vol. 2, pp. 179–182 (2009)

[43] http://morphadorner.northwestern.edu/morphadorner/postagger/

[44] M. Cha, H. Kwak, P. Rodriguez, Y.-Y. Ahn, and S. Moon. ITube, You Tube, Everybody Tubes: Analyzing the World'sLargest User Generated Content Video System. In Proc. IMC2007, ACM Press (2007), 1–14.

[45] Moin Mahmud Tanvee, Mir Tafseer Nayeem, Md. Mahmudul Hasan Rafee ―Move & Select: 2-Layer CAPTCHA Based on Cognitive Psychology for Securing Web Services", International Journal of Video & Image Processing and Network Security IJVIPNS / IJENS vol. 11, issue 5 ,October,2011