

Design and Comparison of Advanced Color based Image CAPTCHAs

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ABSTRACT

CAPTCHA is a technology which has its base in a test called the Turing Test. Alan Turing, proposed this test as a way to examine whether or not machines can think or appear to think like humans. The main purpose of a CAPTCHA is to block form submissions from spam bots- that is automated scripts. Various types of CAPTCHAs are used, which mostly requires users to enter the strings of characters that appear in distorted form on the screen. These types of distorted strings are unable to understand by bots but human can. The CAPTCHA types are either text based or image based. In this paper, a new color based CAPTCHA is described, which provides color based images to human and human will answer to interrogator with color name or so on the question asked during turing test. These colored images can have single color image, more than one color image or it can have images with objects (like monitor, car, flower etc). For these types of questions, the computer machine will be unable to answer and it means unable to break CAPTCHA. This paper describes in detail the proposed CAPTCHA technology principle, method of implementation, variations and comparison of the accuracy rates. We conducted various experiments to measure the viability and usability of this CAPTCHA approach. An accuracy of 100%, 95% and 90% is observed with single color, multi color and color image based CAPTCHAs respectively.

General Terms

Authentication, Security, Algorithms, Human Ease, Human Interaction Proof, Human Factor, Accuracy, Design.

Keywords

CAPTCHA, Image Processing, Spam, Automated Attacks, Character Recognition, Usability, Automated program.

1. INTRODUCTION

CAPTCHA is an interesting topic of research and short for Completely Automated Public Turing test to tell Computers and Humans Apart. The term "CAPTCHA" was coined in 2000 by Luis Von Ahn, Manuel Blum, Nicholas J. Hopper (all of Carnegie Mellon University, and John Langford (then of IBM) [1]. They are challenge-response tests to ensure that the users are indeed human [2]. The use of a CAPTCHA is to block form submissions from spam bots –automated scripts that harvest email addresses from publicly available web forms [3]. A common kind of CAPTCHA used on most websites requires the users to enter the string of characters that appear in a distorted form on the screen.

CAPTCHAs are used because it is difficult for the computers to extract or understand the distorted text or image, whereas it is relatively easy for a human to understand that text or image.

Therefore, the correct response to a CAPTCHA challenge is assumed to come from a human and the user is permitted into the website [4].

The need for CAPTCHAs rose to keep out the website/ search engine from bots. In 1997, AltaVista developed a method to generate a printed text randomly that only humans could read and not machine readers [5]. Their approach was so effective that in a year, "spam-add-ons" were reduced by 95% and patent was issued in 2001. Similarly, Yahoo along with CMU developed CAPTCHA called EZ-GIMPY [6].

CAPTCHAs are mostly used to prevent [7,8]:

- (A) Registering of free online accounts automatically.
- (B) Artificial inflation or deflation of rankings
- (C) Unsolicited mails to other users.
- (D) Attacks by bots to online polls.

It's also important that the CAPTCHA application is able to present different CAPTCHAs to different users. If a visual CAPTCHA presented a static image that was the same for every user, it wouldn't take long before a spammer spotted the form, deciphered the letters, and programmed an application to type in the correct answer automatically. Most, but not all, CAPTCHAs rely on a visual test. Computers lack the sophistication that human beings have when it comes to processing visual data. Human can look at an image and pick out patterns more easily than a computer. The human mind sometimes perceives patterns even when none exist, a quirk known as pareidolia. Ever see a shape in the clouds or a face on the moon? That's your brain trying to associate random information into patterns and shapes.

But not all CAPTCHAs rely on visual patterns. In fact, it's important to have an alternative to a visual CAPTCHA. Otherwise, the Web site administrator runs the risk of franchising any Web user who has a visual impairment. One alternative to a visual test is an audible one which is already purposed by some researches. An audio CAPTCHA [9] usually presents the user with a series of spoken letters or numbers. It is not unusual for the program to distort the speaker's voice, and it is also common for the program to include background noise in the recording. This helps thwart voice recognition. This software will increase in security level but it is very difficult to implement because in speech recognition process the system is working on basis of two methods one is speaker dependent and another is speaker independent. With this type of software human cannot work in the presence of external noise because if human want to enter voice CAPTCHA then he/she need noise less environment to match the voice samples recorded in computer which is not possible all the time.

So there is a need to develop a different and simple CAPTCHA which will be very much user friendly to human and difficult for computer machine [10]. Keeping these things in mind, this paper proposes a special CAPTCHA which will be easy to use and understandable to every user. In this research work, a color based CAPTCHA is proposed, because color is easy to understand for every user, as per accuracy point of view this CAPTCHA has been proposed and implemented.

In this research work the objective is to create a database of different color images, then during turing test the program picks an colored image at random order, presents to the user with different questions like “What is color of the image”, “Enter total number of color”, “Enter middle color in image”, “Enter color of object in image”, “Enter background color”, “Enter color”, etc, now if user responds with correct answer then he/she will pass the test. Two new facilities in this colored CAPTCHA system is introduced here, firstly user can change that CAPTCHA image with change CAPTCHA button option and secondly image will be automatically changed after a fixed certain amount of time. Other main objectives are as given below:

- To study and analysis various CAPTCHA techniques.
- To proposes a Color Based CAPTCHA i.e. to implement the Single Color, Multi Color and Color Image Based CAPTCHA.
- To compare the accuracy rate of CAPTCHAs system implemented.
- To increase the rate of difficulty to passing turing test for computer machine using the concept of color.

Figure 1 illustrates some of the images:

| CAPTCHA IMAGE | CAPTCHA TYPE |
|---|---------------------------|
|  | Single –Color CAPTCHA |
|  | Multi –Color CAPTCHA |
|  | Multi –Color CAPTCHA |
|  | Color Image Based CAPTCHA |
|  | Color Image Based CAPTCHA |

Figure 1: Various color based designed CAPTCHAs.

Various experiments show that humans can achieve a accuracy rates above 90% percent for texting the color of the image. However, finding the single color in multi-color image

Our CAPTCHA approach has higher success rates for humans and low success rates for bots. This method is also more enjoyable for users than the traditional text-based CAPTCHAs.

This paper studies various aspects of Color Based CAPTCHA methods that include its types, generation methods, robustness against attacks and various usability aspects. It presents relative merits and demerits of text and image based CAPTCHA methods. Section 1.1 presents a review of existing CAPTCHA schemes. Section 2 illustrates proposed CAPTCHAs scheme and general methods used for their generation. Section 3 discusses results and discussions of various color based CAPTCHA methods and relative comparison with text and image based CAPTCHAs. A user study was conducted to investigate the performance of our proposed mechanism. The result is encouraging. It also provides the user experience with the proposed scheme. Finally in section 4 and 5, this research work concludes and presents future research directions.

1.1 LITERATURE BACKGROUND: CAPTCHAs

CAPTCHAs can be mainly classified into three classes. Text-Based CAPTCHAs [11,12], Image-Based CAPTCHAs [13, 14] and Sound –Based CAPTCHAs [15]. Text-Based CAPTCHAs is the traditional one and requires user to identify a series of letters by distorted backgrounds and other noise in the image. The examples are shown in figure 2.



Figure 2: Text-Based CAPTCHAs examples (from various websites)

The security of CAPTCHAs is much poorer in real life than it might have appeared to be. Various attacks (in the sense of writing computer programs that automatically solve its challenges) are reported on text-based CAPTCHA. A more recent attack on text-based CAPTCHA method is discussed in [16]. Similar text based attacks are discussed in [17]. These attacks are due to the automated computer vision techniques to make characters readable for OCR [18,19]. To minimize the success rate of these automated techniques, there is need to increase the noise and distortions in the text-based CAPTCHAs. But with more noise and distortions, it also makes difficult for humans to solve and most of the time it also annoys the genuine users [20].

Most of the image-based CAPTCHAs are successful with a success rate of 82.7%. The attacks on image based CAPTCHAs are discussed in [21]. An algorithm to break visual CAPTCHA is given in [22, 23]. Current Image-based CAPTCHAs facing problems of Computer-based recognition algorithms for extracting shape, special point features etc. So to overcome from this problem, images usually are distorted. But more distortions make images even for humans to recognize. Many a times, images were pre-screened to be determined to be difficult to detect up (e.g. no skies, no faces, no text) [24]. If there was a large variance in answers for the

candidate image, it was deemed too hard for people as well discarded. High level of bending or distortion to Text-based, Audio-based (noise effect) or image based CAPTCHA even annoy humans [25,26]. It is proposed to design CAPTCHA which is free from all above problems and give simplicity with ease to users.

Audio-Based CAPTCHA have become an alternative for visually impaired people. Most internet web services include it in addition to text and image CAPTCHAs. It is also shows that distortion methods and levels, just as in text based CAPTCHAs, can have a significant impact on the usability of audio CAPTCHAs. For example, an early test in 2003 showed that the distorted sound in an audio CAPTCHA that was deployed at Microsoft's Hotmail service was unintelligible to all (four) journalists, with good hearing, that were tested [27]. Current audio-based CAPTCHAs have been broken by high-quality voice recognition and noise removal programs [28]. Some existing audio CAPTCHA is highly error prone and time consuming [29]. The CAPTCHA system has attracted considerable attention in the research community [30, 31, 32, 33, 34, 35]. A recent survey on CAPTCHAs research can be found in [36]. Many more schemes have been put into practice, although they are less visible in the literature. However, it appears that this subject is still an art, rather than a science.

2. PROPOSED METHOD

The Text-based CAPTCHA are mostly used, but due to the advances in the OCR techniques urges to create new CAPTCHA challenges that are both attacks free and usable. In this section, a new CAPTCHA approach is presented, which determine legitimate users and at the same time does not annoy them. In the proposed techniques, a database of different color images is created, then during turing test the program picks an colored image at random order, presents to the user with different questions like "What is color of the image", "Enter total number of color", "Enter middle color in image", "Enter color of object in image", "Enter background color", "Enter color", etc, now if user responds with correct answer then he/she will pass the test. Some examples of developed color CAPTCHA is given as follows:

- Single color CAPTCHA.
- Multi color CAPTCHA.
- Colored image based CAPTCHA.

In single color CAPTCHA the interrogator will ask the color of image, in reply user need to enter the correct color of CAPTCHA, for correct answer user will pass turing test.

In case of multicolor CAPTCHA the interrogator can ask different type of questions like

- How many colors are given in image?
- Enter name of color in middle.
- Enter name of maximum %age in image.
- Enter name of left side color.
- Enter name of right side color.
- Enter name of circle or square in image.

In image based CAPTCHA an image will be given and interrogator will ask the question on the basis of image like an image of car is given and the question is

- Enter the color of car.
- Enter background color. etc.

This scheme is depicted in the figures 3 and 4. Both images have been developed using the same algorithm.

2.1 System Description

The CAPTCHA applications are mainly on the web pages, so for implementing CAPTCHA, the scripting language used is PHP [37]. PHP is one of the most popular server side scripting languages running today. It is used for creating dynamic web pages that interact with the user offering customized information. PHP offers many advantages; it is fast, stable, secure, easy to use and open source (free). The popularity of PHP as a technology is estimated from the fact that many popular websites like Facebook, Wikipedia, Wordpress, Baidu, etc. are primarily based on PHP. The reverse turing test is done to secure human interaction assumed services from Web bots.



Figure 3: Multi-color CAPTCHA (Image 1)



Figure 4: Color image based CAPTCHA (Image 2)

2.1.1 User Experiments

Various user studies are done. The first study was done to check whether the system would result in a viable CAPTCHA system in terms of user success rates and bot-failure rates. The second study was done to informally gauge user reactions to the system in comparison to existing CAPTCHAs. All these were uncontrolled studies, so task completion times is not measured.

- 1000 users were recruited from wide –cross section of the city, and included students, sales associates, administrative assistants, engineers and managers. Users participated in the study through the deployed computer and were not compensated for their participation.
- Each user was asked to login through the following figures snapshots login forms. For each trail, the image-ID is recorded.

- In simulation of color based CAPTCHA various questions are asked to user, user reply it with correct color name and easily passed the turing test.

3. RESULTS AND DISCUSSIONS

The results of the human friendliness test are recorded on the basis of turing test conducted. The concept of colored CAPTCHA is very much simple and user friendly. As compared to previous CAPTCHAs, the colored CAPTCHA gives better result due to its applications which are discussed in objective and methodology chapter these are Easy to understandability for all type of users, Simple to use, Security improved, Used friendly, Least complexity, User can solve this CAPTCHA within least amount of time. So the result of this CAPTCHA is analyzed on the basis of recognition percentage. In simulation of color based CAPTCHA various questions are asked to user, user reply it with correct color name and easily passed the turing test. The chance of failed in turing test for users (users must be > 5 years in age) is only if

- user don't know the name of color or
- user entering wrong spelling for any color name

Other than these two conditions this CAPTCHA is 100% accurate and in presence of these conditions, this color based CAPTCHA is 95% accurate (approximate), as per experimental test conducted with a friendly set of users. The tests have been conducted separately on different color based conditions and results are given in following tables and graphs. It also includes figures of percentages of previous CAPTCHAs like in case of Text based CAPTCHA it gives approximate 85% accuracy and audio CAPTCHA gives 70% accuracy (approximate, as per Hacker Intelligence Initiative, Monthly Trends Report #11, June 2012), shadow CAPTCHA gives approximate 80% accuracy. As per security point of view colored CAPTCHA increased more security because computer machine doesn't understand the concept of color and second point after a particular amount of time this CAPTCHA will automatically change the image and question.

Table 1. Test results for color based CAPTCHA

| S.No. | Type | Test Conducted | Pass No. | Fail No. | Pass %age |
|-------|--------------|----------------|----------|----------|-----------|
| 1 | Single Color | 20 | 20 | 0 | 100% |
| 2 | Multi Color | 20 | 19 | 1 | 95% |
| 3 | Color Image | 20 | 18 | 2 | 90% |

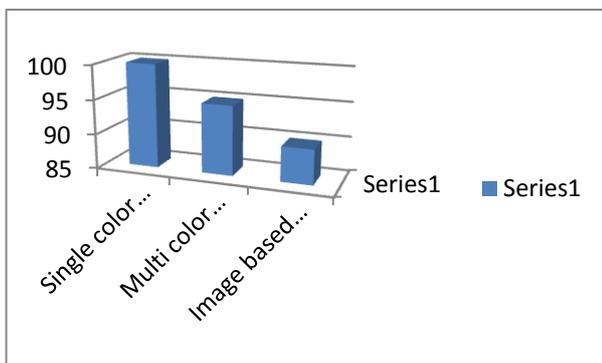


Figure 5: Result analysis of color based CAPTCHA techniques (1)

In the figure 7 and 8, the proposed Color Based CAPTCHA with Text based CAPTCHA, Audio CAPTCHA and Shadow CAPTCHA are compared. The results are shown. It can be easily figure out that our proposed scheme is showing more accuracy rates than the other comparable existing schemes.

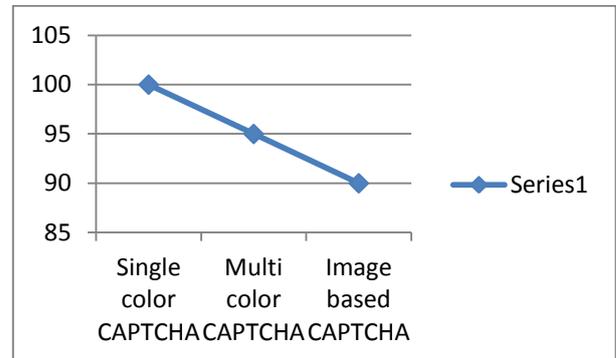


Figure 6: Result analysis color based CAPTCHA (2)

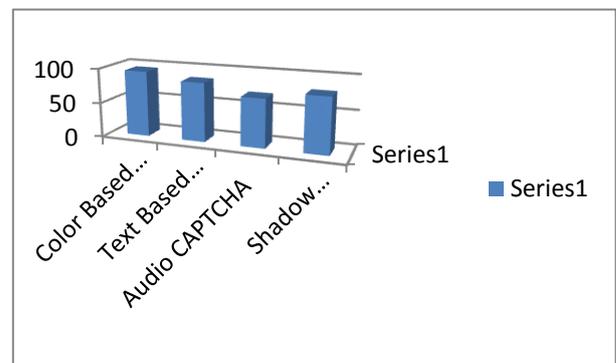


Figure 7: Result analysis of various CAPTCHA techniques (1)

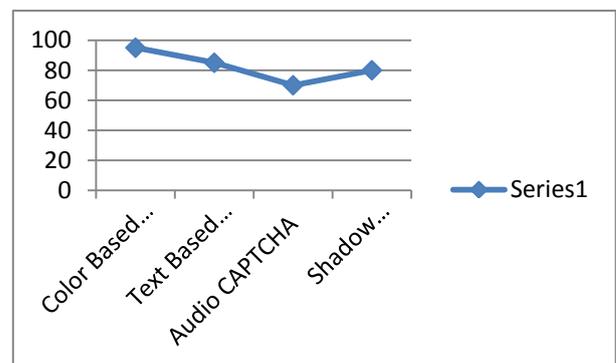


Figure 8: Result analysis of various CAPTCHA techniques (2)

This research work has presented a color based CAPTCHA system, which is very much user friendly, the three types of color based CAPTCHA (Single Color CAPTCHA, Multi Color CAPTCHA and Color Image based CAPTCHA) has been tested and got 95% result, and color based CAPTCHA is also compared to other pervious CAPTCHA systems either it is text based, voice based or any other type of CAPTCHA this colored CAPTCHA is simple, easy to understand and interesting in nature. This system has high success human success rates and low computer success rates. In this research analysis, the user success rate is determined by the average probability that a user can identify the color of the image.

It looklike a fun if you are working with colored CAPTCHA is also added additional facility that user can change the CAPTCHA image and question, secondly image and question is automatically changed after a fixed certain amount of time. Furthermore, this new kind of CAPTCHA provides much more convenience for human to recognize the question, color and answer for reply. Security wise this color based CAPTCHA is also leading from previous CAPTCHAs.

3.1 User Experience

Users experience both the Color Based CAPTCHA as well as Text-Based traditional CAPTCHA. So users asked to experience both the CAPTCHAs. Users have to identify the color of the object and write the color name in the box provided and after they told to solve other CAPTCHA of “decipher text” task, users were told we were measuring their ability to accurately read distorted text. Among the Comments from users who preferred the Color-Based CAPTCHA approach indicated they thought that the method is “easy”, “cool”, “fun” and “faster”. One user stated that he preferred “visual cues over text”, and many users referenced feeling like they were at an eye exam while deciphering the text. Only two of the five users stated their preference as “deciphering text” provided insight to their choice.

4. FUTURE SCOPE

CAPTCHA (standing for Completely Automated Public Turing test to tell Computers and Humans Apart) must have seemed like a good idea when it was first invented in 2000. Spam was beginning to become a major problem on the web and a method was needed to fight back. CAPTCHA at first glance seems ideal: a distorted image that would be instantly recognizable by humans yet incomprehensible to machines. Place some letters in the distorted image and get the user to type them back and bingo: you have stopped your spam problem.

Real life though is rarely so easy. The problem is that spam is profitable, and because of that it's worthwhile to write programs that try to crack CAPTCHAs. The original CAPTCHA examples are now trivial for current algorithms to recognize, and the only option that developers had was to increase the complexity of the distortion. Successive CAPTCHA systems have added more distortion, extraneous lines and shapes, fuzz on the letters, multiple colors and different sizes all in an attempt to stay ahead of the spammers. This had lead to the current situation where the CAPTCHAs are so complex that it's difficult if not impossible for a large proportion of humans to recognize any particular one, yet a sizeable proportion of CAPTCHA breaking bots can solve that same one. But the CAPTCHA proposed here is very easy to understand by user and he/ she can easily pass the test. Our future work concentrates on improving more security and development of more effective colored CAPTCHA.

- Future scope of this research work is more effective CAPTCHA can be developed.
- More security can be increased in future research using the concept of colors.
- Multi colored layered CAPTCHA can be developed by increasing the number of colored layers which layers are changing their color after some fixed amount of time but before entering the answer of the question.
- Multi colored based more than one image CAPTCHA can be developed like number of different color objects in one image can be added

and this CAPTCHA can ask question regarding the color of any particular object.

5. CONCLUSIONS

A good CAPTCHA is not only dependent on how it is to solve by humans, but it is also dependent n how difficult it is to solve by computers. Computer success rate is the probability that a machine can solve the CAPTCHA. Most CAPTCHAs are viewed as intrusive and annoying. Finding just the simple color of the image is quite interesting for users as per study done. The proposed and tested scheme offers some advantages which are easy to understand for all type of users, simple to use, security improved, user friendly, least complexity and user can solve this CAPTCHA within least amount of time because of its simplicity of problem or question. In this research work, a new color based CAPTCHA has been proposed. We have done study that shows users prefer writing the color of image to deciphering text as is required in traditional text based CAPTCHAs. From a security viewpoint, this new research is expected to advance the development of previous CAPTCHA techniques, because computer machine is unable to figure out the name of color but a human can easily understand about the name of the color and demand of question asking during turing test. Further, the system with Single Color CAPTCHA achieves accuracy of 100%, Multi-Color CAPTCHA achieves 95% and finally Color Image based CAPTCHA achieved 90 % accuracy.

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