# A SURVEY ON THE DIFFERENT IMPLEMENTED CAPTCHAS

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***ABSTRACT***

*CAPTCHA is almost a standard security technology, and has found widespread application in commercial websites. There are two types: labeling and image based CAPTCHAs. To date, almost all CAPTCHA designs are labeling based. Labeling based CAPTCHAs refer to those that make judgment based on whether the question "what is it?" has been correctly answered. Essentially in Artificial Intelligence (AI), this means judgment depends on whether the new label provided by the user side matches the label already known to the server. Labeling based CAPTCHA designs have some common weaknesses that can be taken advantage of attackers. First, the label set, i.e., the number of classes, is small and fixed. Due to deformation and noise in CAPTCHAs, the classes have to be further reduced to avoid confusion. Second, clean segmentation in current design, in particular character labeling based CAPTCHAs, is feasible. The state of the art of CAPTCHA design suggests that the robustness of character labeling schemes should rely on the difficulty of finding where the character is (segmentation), rather than which character it is (recognition). However, the shapes of alphabet letters and numbers have very limited geometry characteristics that can be used by humans to tell them yet are also easy to be indistinct. Image recognition CAPTCHAs faces many potential problems which have not been fully studied. It is difficult for a small site to acquire a large dictionary of images which an attacker does not have access to and without a means of automatically acquiring new labeled images, an image based challenge does not usually meet the definition of a CAPTCHA. They are either unusable or prone to attacks. In this paper, we present the different types of CAPTCHAs trying to defeat advanced computer programs or bots, discussing the limitations and drawbacks of each.*

***KEYWORDS***

CAPTCHAs, Labeling,Segmentation, Image recognition

## 1. INTRODUCTION

With the development of the computer applications in different fields, internet has made a tremendous progress and become a special need in human life. It has applications in a wide range of daily affairs including trade, education, daily purchases and dialogues take place with the use of Internet. One of the common actions in the Internet web sites, especially commercial and administrative ones, is to fill out registration forms for certain purposes. Unfortunately, there are some programs which automatically fill out these forms with incorrect information to abuse the site, or automated programs which are usually written to generate spam.

Thus, differentiating between a user and machine over the internet has significant importance in the fields of internet security, artificial intelligence, and machine learning. Currently, HIPs takes the role of preventing robots from signing up for free online services (such as email accounts), abusing online polls, providing biased feedback, and spamming innocent users.

Dhinaharan Nagamalai et al. (Eds) : COMIT, AISCA - 2019
pp. 01–11, 2019. © CS & IT-CSCP 2019 DOI: 10.5121/csit.2019.90101

Completely Automated Public Turing test to tell Computers and Humans Apart is class of automated challenges used to differentiate between legitimate human users and computer programs or bots on the internet. Thus, it plays the same role of HIP.

In 1997 Andrei Broder, Chief Scientist of AltaVista, and his colleagues prevented automated machine from adding of URLs to their search engine. They developed a program that permitted human's entrance but not machine's entrance. In 2000, Bots were annoying genius chatter by advertising sites and elicit personal information. CMU researchers: Manual Blum, Luis A. von Ahn and John Langford coined the term "CAPTCHA" that was pointed to "capture", and used CAPTCHA in order to solve Yahoo's chat room problem. In 2001 Allison Coates, Henry S. Baird and Richard Fateman of UC Berkeley developed Pessimal Print: that is low–quality of printed text images used certain rate of distortion [1].

The notion of a machine imitating human intelligence was first addressed as early as 1950 by English mathematician and logician Alan Turing [2]. Acknowledged as the father of modern computing, Turing recognized that computers might eventually be able to imitate human thought in very convincing ways. Therefore, he suggested what is now known as the Turing test, where a human converses with a computer without seeing it. If the human is convinced by the computer's answers that it is human, then the machine passes the test and is deemed to have some level of human-like intelligence.

The idea of a reverse Turing test, where a computer attempts to differentiate between a human and a computer, arose during the late 1990s when computer programs began to imitate humans in order to misuse the resources of internet-based systems.

HIPs [3] are a slight modification of a reverse Turing test, where the challenge is administered by a machine and taken by a human. The burden is on the human participant to convince the machine that he is human. Furthermore, the challenge should not be solvable by any machine. Notice the paradox that this creates: the machine can automatically create, administer, and grade a test that it itself cannot pass. Tests developed to differentiate these programs from real humans took the form of what would come to be known as CAPTCHAs.

## 2. EXISTING SOLUTIONS

Many CAPTCHA implementations were designed by different companies (Microsoft, Yahoo, AltaVista) in order to offer a more secure online environment. An environment that distinguishes internet communications originating from humans from those originating from software robots. This section is going to present the different types of CAPTCHAs trying to defeat advanced computer programs or bots, discussing the limitations and drawbacks of each.

### 2.1 TEXT-BASED CAPTCHAS AND THEIR LIMITATIONS

In character labeling based CAPTCHA designs, the computer renders a sequence of letters after distorting them and adding noise. The user is asked to tell what characters they are in order, and will pass the test if the characters typed (new labels) match exactly those known to the server (known labels). Character labeling CAPTCHAs are the most widely used CAPTCHAs. The popularity of such schemes is due to the fact that they have many advantages [4], for example, being intuitive to users world-wide (the user task performed being just character recognition), having little localization issues (people in different countries all recognize Roman characters), and of good potential to provide strong security (e.g. the space a brute force attack has to search can be huge, if the scheme is properly designed).

In 1997, AltaVista developed the first concrete implementation of a CAPTCHA. AltaVista had been receiving automated URL submissions to their search engine database by spam bots. A group of researchers from the Digital Equipment Systems Research Center were contracted to develop a solution to prevent such an attack [5]. To combat this, the team of developers created a verification system that makes suggestion of recognizing handwritten images. However, they soon realized that although an image containing text was a step in the right direction, it could easily be foiled by use of OCR software. Optical Character Recognition (OCR) software is designed to translate images of text into a machine editable form. The team researched the limitations of scanners with OCR capabilities, and exploited the weaknesses of the OCR systems when rendering their CAPTCHAs. In order to improve OCR results, the manual suggested using similar typefaces, plain backgrounds, and no skew or rotation. To create an image that was resilient to OCR, they did the exact opposite of the suggestions.

In the summer of 2000, Yahoo also began to experience a similar problem where their chat rooms were being spammed by chat bots. This gave birth to the CAPTCHA project. The researchers provided yahoo with three options (see Fig. 1): EZ-Gimpy renders a single, distorted English word on a noisy background, Gimpy-r renders a random string of distorted characters on a noisy background, and Gimpy renders 5 pairs of overlapping distorted words (of which you must type 3).


(a) EZ-Gimpy CAPTCHA

(b) Gimpy-r CAPTCHA

(c) Gimpy CAPTCHA

Figure 1 - Examples of EZ-Gimpy, Gimpy-r, and Gimpy CAPTCHAs

In June 2003, shape context matching was used to solve Gimpy with 33% accuracy and EZ-Gimpy with 93.2% accuracy [6]. In June 2004, distortion estimation techniques were used to solve EZ-Gimpy with 99% accuracy and Gimpy-r with 78% accuracy [7]. Due to the limited and fixed size of EZ-Gimpy's dictionary, every challenge image was easily compared against a template database. The distorted template image with the best correlation was returned as the result. However, Gimpy-r does not rely on a dictionary, and therefore requires local distortions to be removed via distortion estimation techniques.

In 2001, researchers at the Xerox Palo Alto Research Center and the University of California at Berkeley synthesized low quality images of machine printed text using a range of words, fonts, and image degradations .Following Baird's quantitative stochastic model of document image quality [8] and a list of problematic OCR examples, noise was introduced into the rendered strings by using two image-degradation parameters, blurring and thresholding (see Fig. 2). A couple of years later, a reading based CAPTCHA known as Baffle Text [9, 10] was developed (Fig. 3). Baffle Text exercised the Gestalt perception abilities of humans, humans are extremely good at recognizing and understanding pictures despite incomplete, sparse, or fragmented information, where as machines are not.

Figure 2 - PessimalPrint CAPTCHAs

Figure 3 - Baffletext CAPTCHAs

OCR systems separate recognition into two sub tasks, segmentation and classification. In 2004, researchers at Microsoft Research exploited the fact that segmentation is much more difficult than classification for OCR systems. So, they developed a CAPTCHA based on hard segmentation problems, as opposed to hard classification problems. Although character classification was still required, the main challenge was correctly segmenting the string. Another contribution was the observation that website owners with CAPTCHAs have the advantage in the battle against CAPTCHA attackers. This is because CAPTCHA generation is a synthesis task while attacking a CAPTCHA is an analysis task. Analysis is orders of magnitude more difficult than synthesis. In the synthesis task, the creator has the ability to use randomness and creativity, while in the analysis task, the attackers are tightly constrained by the decisions made by the creator.

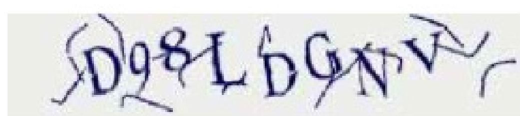


Figure 4 - Microsoft's Segmentation-Based CAPTCHAs

A formal study of user friendliness for transcription tasks was conducted at Microsoft Research. They studied the effects of varying the distortion parameters and attempted to determine the optimal parameters where the CAPTCHAs prove hard for machines but easy for humans. As researchers found in the past, the most effective CAPTCHAs are segmentation based challenges, which continues to be a computationally difficult task (see Fig. 4). In 2004, researchers at Microsoft Research attacked several commercial CAPTCHA implementations and achieved high accuracy (80%-95%) [11]. Neural networks were used to perform character recognition. Their attacks had the most difficulty with the segmentation task, not the recognition task. Therefore, they suggested that researchers focus their efforts on building CAPTCHAs which rely on the segmentation task instead of the recognition task. It was later confirmed in July 2005 that computers are as good as, or better than humans at classifying single characters under common distortion and clutter techniques. However, other researchers have developed an attack that recognizes the “hard-to-segment” Microsoft CAPTCHA more than 60% of the time.

Figure 5 presents some character based CAPTCHAs that can be sampled from the web while signing up for free e-mail accounts with Mailblocks (www.mailblocks.com), MSN/Hotmail (www.hotmail.com), Yahoo (www.yahoo.com), Google (gmail.google.com), running a whois query at Register.com (www.register.com) or searching for tickets at Ticketmaster (www.ticketmaster.com).

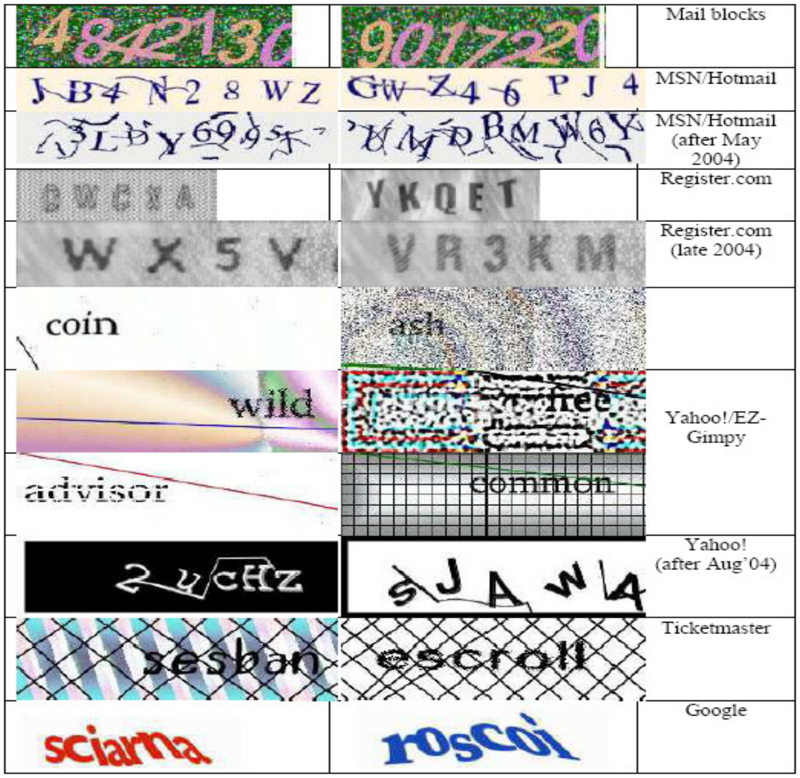



Figure 5 - Examples of Various Character Labeling CAPTCHA

Solutions to Yahoo (version 1) CAPTCHAs are common English words, but those for Ticket master and Google do not necessarily belong to the English dictionary. They appear to have been created using a phonetic generator. Examining the changes in MSN, Yahoo, and Register.com HIPs, it can be noted that these CAPTCHAs are becoming progressively more difficult. While MSN introduced more arcs as clutter, Yahoo gave up their language model and replaced simple textures and grids with more random intersecting lines and arcs. Register.com's update was minor as they introduced digits into their character set.

In [12] Chellapilla et al. have discussed the various issues when designing a character labeling based CAPTCHA. They can be summarized as follows: Character set, the character set to be used in the CAPTCHA. Affine transformations, which are Translation, rotation, and scaling of characters. Adversarial clutter represented as Random arcs, lines, or other simple geometric shapes that intersect with the characters and themselves. Image warp such as elastic deformations of the CAPTCHA Image at different scales i.e., those that stretch and bend the character itself (global warp) and those that simply jiggle the character pixels (local warp) and Background and foreground textures which are used to form a colored CAPTCHA image from a bi-level or grayscale CAPTCHA mask.In [13], each character fragment is labelled in order from top to bottom and left to right, and then the components are combined on the idea of jigsaw puzzle to generate candidate characters.

[14] provides a systematic analysis of text-based CAPTCHAs and innovatively improve their earlier attack on hollow CAPTCHAs to expand applicability to attack all the text CAPTCHAs. With this improved attack, they have successfully broken the CAPTCHA schemes adopted by 19 out of the top 20 web sites in Alexa including two versions of the famous Re CAPTCHA. With success rates ranging from 12 to 88.8% (note that the success rate for Yandex CAPTCHA is 0%), they demonstrate the effectiveness of their attack method. It is not only applicable to hollow CAPTCHAs, but also to non-hollow ones.

[15] present a novel segmentation and recognition method which uses simple image processing techniques including thresholding, thinning and pixel count methods along with an artificial neural network for text-based CAPTCHAs. We attack the popular CCT (Crowded Characters Together) based CAPTCHAs and compare our results with other schemes. As overall, our system achieves an overall precision of 51.3, 27.1 and 53.2% for Taobao, MSN and eBay datasets with 1000,500 and 1000 CAPTCHAs respectively.

## 2.2 IMAGE-BASED CAPTCHAS AND THEIR LIMITATIONS

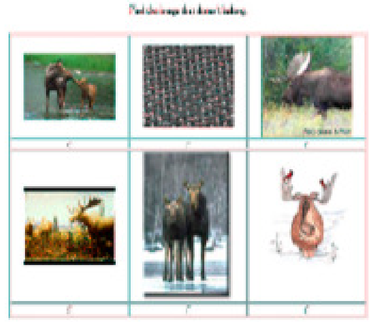
While requiring a user to recognize distorted characters is the most common type of CAPTCHA, semantic image understanding tasks have also been proposed. Chew and Tygar from the University of California at Berkeley investigated a set of three image recognition tasks using a fixed English dictionary of 627 words and Google Images [16, 17]. The Naming images, where the use should determine the common term associated with a set of 6 images (see Fig. 6a). They used approximate matching to grade the responses. Second, Distinguishing images where the he should determine if two sets of images contain the same subject, and finally identifying anomalies, where he should identify the “odd one out” from a set of 6 images (see Fig. 6b)

The problems which affected human performance were evaluated and tested during an in-depth user study. Two formal metrics for evaluating CAPTCHAs were also proposed as well as attacks on the three image-based CAPTCHAs. The first metric evaluated CAPTCHA efficacy with respect to the number of rounds of a CAPTCHA and the second metric measured the expected time required for a human to pass the CAPTCHA.

In late 2003, researchers at Microsoft Research argued that the most familiar objects to humans are human faces. They developed a CAPTCHA designed to confuse face recognition algorithms while still being easy to use [18, 19, 20]. Images are automatically synthesized from facial models and the task is to locate and click on the 4 corners of the eyes and 2 corners of the mouth (6 points in total). However, the images looked eerie to many users (see Fig. (7)). For this reason, the system was never adopted.

A similar approach to face recognition based CAPTCHA was developed in 2006 [21]. Photographs of human faces were mined from a public database and distorted. The user is then prompted to match distorted photographs of several different humans. This CAPTCHA has the benefit of being language independent (ignoring textual instructions for completing the task).

6 a - The Image-Based Naming CAPTCHA



6 b - The Image-Based Anomaly CAPTCHA

Figure 6 - Examples of Imaged-Based Naming and Anomaly CAPTCHAs

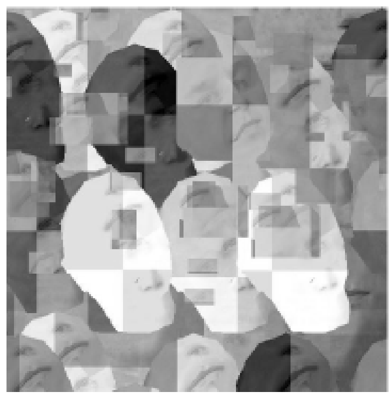


Figure 7 - Example of an Artifacial CAPTCHA

In January 2005, some researchers thought that current CAPTCHAs were too demanding of legitimate human users. Instead, they proposed Implicit CAPTCHAs which require as little as a single click [22]. The challenges were so elementary that a failed challenge indicates an attempted bot attack. The authors suggest disguising necessary browsing links in images and claim that bots would not be able to find these hidden links (see Fig. 8). While the usability of the system is attractive, the system could easily be attacked on a case-by-case basis. For example, if the user is told to click on a specific, static place on an image, an attacker would only have to solve this once (challenges are static and therefore are reused). This type of CAPTCHA may work for low traffic or low value services, but it would never survive in a large scale application, as it is impossible to automate the generation of challenges.

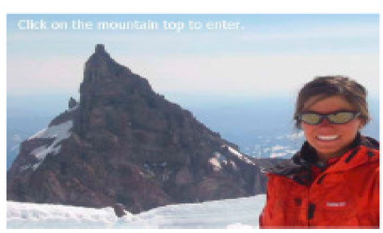



Figure 8 - CAPTCHA - User is Instructed to Click on Top of Mountain

One of the more interesting CAPTCHA ideas appeared in January 2011 as a result of an effort by social-networking giant Facebook. The company is currently experimenting with social authentication in an effort to verify account authenticity (see Figure 9).

> "We will show you a few pictures of your friends and ask you to name the person in those photos. Hackers halfway across the world might know your password, but they don't know who your friends are."
>
> — Alex Rice, Facebook, A Continued Commitment to Security

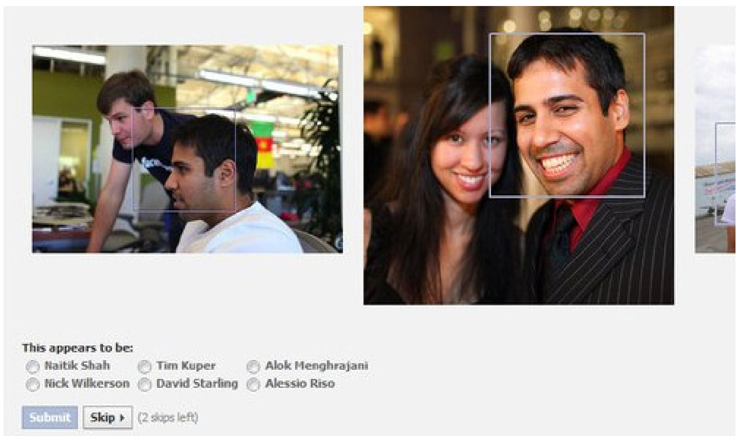



Figure 9 - Facebook's Friend Recognition Test

What makes Facebook's project slightly different than the normal CAPTCHA is that the authentication is supposed to filter out human hackers rather than machines.

There is potential for Facebook to roll this out across the Web. With 600 million users and millions of websites that integrate with it, Facebook has the ability to use this social recognition CAPTCHA in a big way, and it could prove to be easier than text recognition.

There is one problem. People does not actually know there friends. The reality is that friend requests are exchanged between even the barest of acquaintances, remembering names to go with all those faces could be challenging. As intuitive and intelligent as Facebook's idea might be, it is ultimately flawed because, as humans, we do not follow the rules.

Significant amounts of research have gone into the development of CAPTCHAs over the past 12 years. The first CAPTCHAs required users to transcribe strings of distorted text. Later, more advanced CAPTCHAs which relied on image understanding emerged. Text based CAPTCHAs were usable but easily defeated, while image based ones were affecting human performance. The challenge in designing an effective CAPTCHA is making a compromise, CAPTCHA must not only be human friendly but also robust enough to resist computer programs that attackers write to automatically pass CAPTCHA tests.

Bongo CAPTCHA is named after Mikhail M Bongard who published pattern recognition problems book. In Bongo [23] visual based pattern recognition is provided for the user to solve. The Figure 10 shows an example of Bongo CAPTCHA. It contains 2 block series namely the right block and the left block series. The series of the right block differs from the left blocks, and the user should identify the characteristic which set them apart.

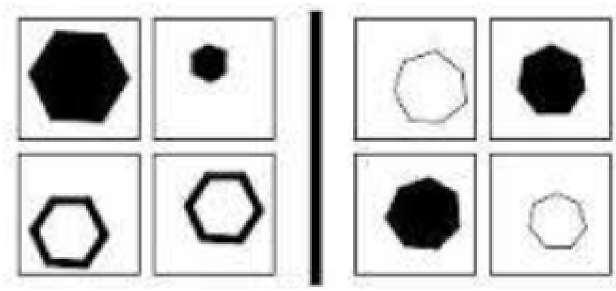


Figure 10- Example of Bongo catpcha

## 2.3 VIDEO BASED CAPTCHA

Video based CAPTCHA system [24] uses a technique in which the video contains few random words. The Figure 11 shows an example of Video CAPTCHA. When the video is played the user has to submit those displayed words. The users need not to wait until the video finishes for submitting the displayed words. The user passes the test only when the ground truth tags which are produced automatically matches with the user entered tags.


Figure 11- Example of Video based CAPTCHA

## 2.4 PUZZLE BASED CAPTCHA

Puzzle based CAPTCHA can either be a picture based puzzle or a mathematical puzzle. The Figure 12 shows an example of Puzzle based CAPTCHA. In a picture based puzzle, the picture is divided into segments and is shuffled. Each segment will have a segment number followed by the next segment. The user has to combine these segments properly to form a correct complete picture [25]. The mathematical puzzle is 100% effective and can be integrated into login, registration forms in the website for secured access. The user has to solve the math puzzle provided in order to gain the access to secured services.

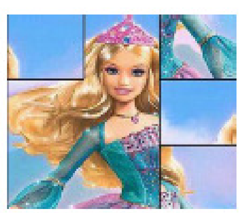


Figure 12 - Example of Puzzle based Captcha

## 3. CONCLUSIONS

CAPTCHA plays important role in World Wide Web security where it prevents Bot programsand Hackers from abusing online services. In this paper, we have provided a set of techniques that would allow for the system to be secure and less vulnerable to bot attacks. It is a well synthesized CAPTCHA, where the attacker should pass three obstacles in order to bypass it.

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