

# CAPTCHA: Using Puzzle Based Arithmetic Operations

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**Abstract**—CAPTCHAs are standard mechanisms used on many websites for security against being abused by automated programs. Captcha is an automated test designed to be easy for humans that cannot be passed by a current computer program. It is a universal barrier to shield open web assets from robots. Many CAPTCHAs (Completely Automated Public Turing test to Tell Computers and Humans Apart) have already been proposed such as graphical based, text based, audio based, puzzle based. We propose a simplified mathematical questions-based CAPTCHA. Design and implementation of this CAPTCHA falls into the realm of artificial intelligence. Our aim is to use this CAPTCHA as a key to secure the internet based applications. The person whoever needs to get access to the data will need to read the code above it and rewrite it in the specified manner. This process usually involves a small test given by a computer to its user which is in turn generated and graded.

## I. INTRODUCTION

CAPTCHA is a bacronym for (Completely Automated Public Turing test to tell Computers and Humans Apart). Security is condemning in any technology-driven which operates on computer systems. The main goal in security is to deliver a cryptographic system that are computationally infeasible for attackers to get access to the system. In designing a system many aspects should be taken into consideration, one of the major portion is security which stands to be very important. For instance, in RSA the technique used is integer prime factorization, Digital Signature Algorithm(DSA).

Now a days most of the emails, post's on social networks contains spam. They do it in order to get benefited by stealing the data from personal computer, they get money by advertising through sending spam mails. A person cannot do it manually by hand creating more number of accounts. So, they started using specialized software with the help of bots and they get their job done. The idea of such a program emerged from real world issues confronted by web organizations. Some of the companies which are facing real world problems like yahoo provides free email accounts. Some fake companies are using bots to create thousands of account so that they could send out junk mails. The problem solving was, to require a CAPTCHA test for every new account opening. Captcha helps in providing a shield from spam and secrete messages decoding by giving the user a simple straightforward test that demonstrate the truth of existence is a human not a computer

attempting to perform unauthorized access and crack into a password protected account.

## II. BACKGROUND STUDY

The term CAPTCHA came into play in the year 2003 by Luis von Ahn et al, a test that can differentiate a human and a bot. CAPTCHA can be in any of the forms of text, audio, video or image which can be easily identified and solved by a human but not by a machine or a computer program. Text based CAPTCHAs are used in real time applications. Complexity of a CAPTCHA can be intensified by systematically adding noise, distortions and close-fitting of characters. CAPTCHAs are classified based on the type and level of distortion that whether they are character, numerical or images. Types of CAPTCHAs include:

1. Based on Text
2. Based on image
3. Based on audio
4. Based on video
5. Based on puzzle

Text based CAPTCHA: it is a simple question and answer type. The user is asked to identify the text or answer a sample question. These text based CAPTCHAs can be cracked by identifying the characters and digits in text through optical character recognition(OCR) Technique. Image based CAPTCHA: In this Graphic-based CAPTCHAs the users have to guess the images that have the similarity. The advantage of this CAPTCHA is that pattern recognition is hard AI problem and hence it might be difficult for an attacker to break this using pattern recognition technique.

Audio based CAPTCHA: These are based on the sound based systems. These are designed for visually disabled people. A sound clip is distorted and presented it to the user and asked to enter the exact words and letters rendered through keyboard. Words and characters that has similar pronunciation are always ambiguous. Video based CAPTCHA: In this video based CAPTCHA few tags are given to the user that are described in the video and asks the user to watch the video and select the correct tag from the given. This is a less implemented CAPTCHA. Downloading and watching large sized files is not easy.

Puzzle based CAPTCHA: In this the user is given chunks of an image and asked to rearrange them such that it forms the original picture. This type is not easy as it consumes more time and figure the original arrangement.

### III. RELATED WORK

In[1] Anjitha and Rijin comprises of improving the Captcha scheme with movement through video embedding. To keep the objects in motion arbitrary movements are provided, along with that background texture is changed, that helps for dynamic change in target and background features. The main theme of this paper work is provides a set of characters which are moved in dynamic fashion, user should identify the correct code word. In[2] Artem and Andrey proposed a new theory based on robustness and configurable. They used cloud-based Captcha services(uses a animated hand gestures), in order to pass the test user needs to identify words and type the sequence of characters. In fact, each and every single captcha services make them accessible to user over the internet, yet they more often won't utilize the maximum potentiality of that approach. According to[3] Anuj Thankur and Rohit Chaware had introduced a new approach called ROOT(Reading Oriented Overlapping Text). This paper is all about text based Captcha. The security for this lies on the strength to defend recognition and segmentation attacks. In this the text based Captcha, it consists of alphanumeric letters which are computer generated and hand written, along with them a reading pattern is generated which helps to use the same one for many number of times. In[4] they proposed an advance Captcha technique, there technique emphasis mainly on human ability recognition which is not available in robots. With the help of leveraging the writing features in developing Captcha, they used four different languages to generate multilingual Captcha. Maha and Ahmed used the special features of handwriting which are understandable only by humans, it contains French, Spanish along with English. In[5] they proposed a new approach that defends the spyware attacks. Traditionally used Text-Based scheme stores the same key in the loggers which is very easy for the spyware to decode and steal the computer's use. They want to overcome this spyware attacks by using click-based Captcha which uses a distinct approach. In their database a set of images were present, with the help of those images Image Transformation is done by doing image orientation(rotating), cropping (resize), skew alteration(tilted). It gives a set of images on top of the grid view, user has to identify in all possible ways. In[6] they proposed a new approach which is puzzle Captcha based on image Captcha technique. They developed project using HTML, CSS, scripting language and used a evolutionary prototyping in building. User is allowed to drag and drop all the images to resultant box and they should be in organized manner with their suitable sequences. The design of this proposed system contains three major parts image collection, processing engine and interface. Images are collected with a size of 200 X 200 pixel size and for every image there is a label followed by specific number of that image. Processing engine will be used to cut the image, which

are allocated randomly and this helps in process of drag and drop. Interface consists of two sections cutting image and main image, down to main image there is answer box. Images should be dragged from left side cutting image to answer box and should exactly match with the main image. In[7] they proposed image recognition based Captcha for security increase in web centric applications. In this method they used distorted faces to make a picture for the Captcha test. User should recognize well known appeared in the image and have to choose a name from given list. They used feature-line morphing approach to distort faces into well known cartoon image or animal. There are two databases one with human faces and other with cartoon images, the images contained are well known for people belong to the industry of arts, political, cinema. For every image there is respective name database to create a list of names for user interface. The user have to recognize three faces in a row. They claimed that this approach is efficient and difficult to crack by face recognition software, by testing it with three kinds of face recognition systems. In [8] proposed sound-based Captcha which eliminate the interval time between synthetic voice and user voice. The user has to repeat a voice that is written above in the textfield, which is chosen from a predefined book. The produced sound document will be examined naturally to identify whether the client is human or bot. Gao and Liu experiments proved that human success rate is extremely high 97 percent and the attack software pass rate is only 4 percent. To extract the characteristics of audio file from the produced file by client, they used short-term Fourier analysis which divides into segments for processing. In[9] Johnson and Tanmay proposed a new approach to blacklist the IP address, if the number of failure attempts are more from the same IP. HTTP count filter is used to suspect IP and the Captcha method is used to find out the counter check from the respective IP's. The black listed IP's are stored in the ?IP table?, which is used at the starting of the approach to check and compare, it is from a legitimate user. If the IP is not in the blacklist it will redirect to prove it as Human or bot by Captcha test. In [10] Tao and Wang proposed approach is based on image Captcha technique. They want to increase the efficiency of using captcha by adding an extra functionality like applying invented colors for the imaged captcha. It's a dynamic approach, the characters and the background colors are inverted. The interference line are combined with the image and with the use of multi frames they made sure that it has a better visual effects. The project is targeted on color because the human has eyes to make a difference between colors but not the bot, they treat each color as a different one even if they are kind of similar. In[11] proposed a technique based on Gestalt Geometric Captcha. Most of the Captcha techniques require database to store images and shuffle randomly but this approach doesn't require. Using the law of focal point theory, mostly human eye tends to point at the center of the image. They used geometrical shapes to develop Captcha image in which their slice of the part similar to geometric shape is removed to generate. User were asked to focus on black shapes only which are in center.

Assumptions based can be identified only by humans and are difficult for the bots because they can see only in physical boundaries perspective. According to [12] paper presents various details of CAPTCHAs such as generation methods, types of captchas, various usability aspects and robustness against security attacks. This also discusses the downsides of creation of ambiguous characters or images and also discusses the level of maximum and minimum distortions. It also discusses about the usability issues that are to be addressed while designing a captcha such as use of interface space, color and simple user interface such that it becomes easy for the user to answer and integrate the webpage with high accuracy. In [13] this paper authors discuss about the capability of humans interpreting the handwritten text, When compared to machines. A review of handwriting recognition algorithms is being made such as parallel classifiers and combinations, lexicon driven and lexicon free, analytical and holistic methods. Transformations such as noise, segmentation, normalization and lexicon are applied on the images of hand writing which makes the task of recognition even more difficult for the machine whereas the human can still easily identify the hand written text. This [14] paper describes a survey done on different kinds of Captchas such as text, audio, video, image and puzzles. It explains the drawbacks of different types of captcha such as problem in identifying text due to multiple fonts, sizes and wave motions, problem in identifying image due to low vision or blurring of image, problem with the size of videos, consumption of more users time by puzzle captchas etc., this paper also lists out various applications of different types of captcha. In [15] this paper three CAPTCHAs are proposed and implemented to distinguish humans from software robots in the online environment. The above three captchas are based on naming images, distinguishing images, and identifying an anomalous image from the given sets of images. In the naming images CAPTCHA, the user is given six images and asked to identify the common term associated with images. In distinguishing images CAPTCHA, the user is given two sets of images which individually contains same subject. User is asked to verify if the images in a set have the same subject or not. Identifying anomalies CAPTCHA six images are given to the user in which five images has a common subject and the sixth one has a different subject. User is asked to identify the anomalous image. According [16] paper describes a new way of designing CAPTCHA such as splitting image in many parts with random rotation value and adding different kinds of random lines. The paper proposes the IND-OCPA-P model for the security analyzation of the given model and encryption schemes supporting the efficient and high level querying over the encrypted data. In [17] paper describes that the user is given options to select types of CAPTCHA. This model provides the user with a window to choose types of CAPTCHA. In this proposed model user is provided with 5 types of CAPTCHA questions namely analytical, mathematical, textual, general and image based. User can select an option and user is provided with 10 minutes of time to solve the CAPTCHA. In [18] paper proposes a new CAPTCHA based on moving

object identification and tracking problems, which is referred to as biological motion vision model. A framework is also put forward to make the Edge mutation based CAPTCHA generation algorithm. This animation CAPTCHA will be able to resist the static OCR technology as the attacker can log in to the test service system only after solving the moving object recognition problem. In [19] this paper handwritten images were used for CAPTCHA to enhance web security. The ease of recognition of handwritten text in images for human beings is greater when compared to other machines or programs. A technique is used in this to generate colored images of hand written text which also includes numbers which has randomness associated with it.

#### IV. ARCHITECTURE DESIGN

##### A. Methodology:

With the latest amendments in technology and software services there are many possibilities of exploiting the resources made available for humans by bots or computer programs. To avoid this, they have come up with an idea of posing a challenge to a human or a computer user that can differentiate humans from machines which is basically a Turing test known as CAPTCHA. We hereby came up with an idea of implementing an image based arithmetic CAPTCHA that asks the user to perform a basic arithmetic operation on specific positioned images. The images are composed of numbers ranging from 0 to 99 which are randomly selected using a random function. Even though many CAPTCHAs have been broken earlier using some techniques, it is all a matter of time taken to break that CAPTCHA. The evaluation of CAPTCHA depends mainly on two factors. They are

- \* The number of attempts(CAPTCHAs) a user gives and
- \* Number of CAPTCHAs solved correctly

So, based on the above factors we have implemented a CAPTCHA that merely involves a basic arithmetic operation which can be easily solved by almost every user. As some of the users may not be comfortable with multiplying or dividing two large numbers, we use only Addition and Subtraction operation in our CAPTCHA. Thus, the ratio of number of CAPTCHAs solved correctly to the number of attempts is higher.

##### B. Algorithm:

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Algorithm for CAPTCHA:

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1. Start Procedure ARITHMETIC CAPTCHA
2. Generate a random number images between 0 to 99
3. *Begin*
4. *for*( $i = 0; i < 10; i++$ )
5.  $I_{(i,j)} < -random(imageset)$
6. *for*( $j = 0; j <= 2; j++$ )
7.  $A[i] < -Select2positionsrandomlyfromtheabove9positions$
8. *Endfor*
9. *Endfor*

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10. answer = Userinput[Textbox]
11. If(random(add||sub)A[i])isequalto- > answer
12. Then
13. Giveaccess
14. elsegotoStep3
15. EndProcedure

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### C. Architectural Design

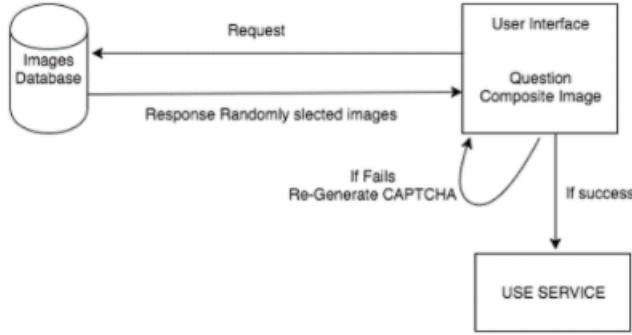


FIG1: System Architecture

### D. Implementation of arithmetic CAPTCHA

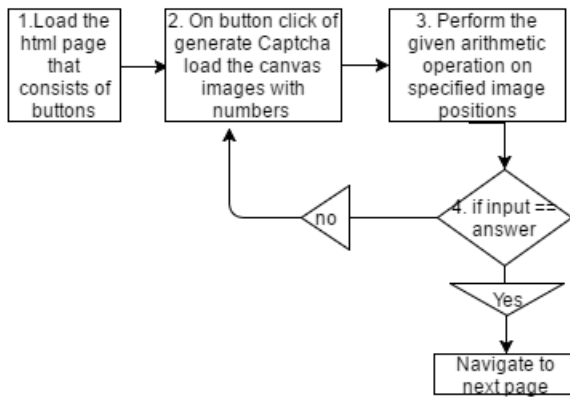


FIG2: Example of generating an arithmetic CAPTCHA

Step 1: Set the content of the Canvas. We generate the images with random numbers embedded on them. We choose nine numbers between 0 to 99. To make the Captcha simple and easy, we do not consider numbers above 99 as it is not easy for a user to perform arithmetic operation on large numbers. Large numbers also waste user's time. Step 2: on Click event of a get Captcha button from the Interface, the Canvas is made visible. This is implemented so that it can delay an attacker who is trying to break in using brute force method. Step 3: Here two positions are randomly selected from the above nine positions which are given in the question. So, one of the arithmetic operation (addition or subtraction) is to be performed on those positions. Step 4: User is asked to enter the calculated value through a text box which is stored in a variable. This value is compared with the precomputed value on those specified positioned images. If the Entered value is equal to the precomputed value, the user is navigated to the destined webpage or else the canvas and the question are reloaded.

In this paper an effective way to deal with the image based Captcha which is executed using the randomly generated numbered images during the run time into the canvas (composite box). The most important point is to make a test that creates images and generates randomly into the canvas which uses a 3X3 matrix where it can fit 9 generated images. The steps involved to implement are as follows:

Put image here UI screen shot

Fig: user interface for the image-based CAPTCHA which shows the generated images and arithmetic operation to solve.

we have implemented the proposed technique for sample website. We used HTML, java script languages are the tools used in developing the project. The operations that every user must perform in order to use our service.

The images are generated dynamically. These are kind of images which have a number inside the image, along with filling and stroking like doing distortions the generated images.

The questions are generated randomly by changing the operation and positions for very repetition.

After reading the question on top of the page, user should click the GETCAPTCHA button in order to know what exactly he/she should do.

The above mentioned positions should be identified by the user.

After identifying user should calculate the arithmetic operation based on the question and positioned numbers.

The calculated value should be entered into the textbox below; after that user should click the SUBMIT button in order to know use a service.

## V. EVALUATION

As mentioned earlier, the aim of the project is to come up with a novel idea of generating an arithmetic CAPTCHA that can secure a system resource from being drained by a bot or a computer program, in simple to differentiate between a bot and a human. There are basically two kinds of arithmetic operations performed in this CAPTCHA. They are Addition Operation, and Subtraction Operation.

The operation to be performed is randomly selected along with the position of images on which these operations are to be done. This is tested on a user before accessing a webpage or a resource to check whether he is a bot or human.

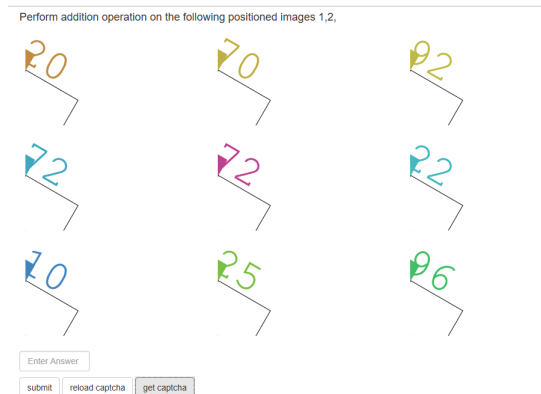
### A. Evaluation Screenshots

Perform addition operation on the following positioned images 1,2,

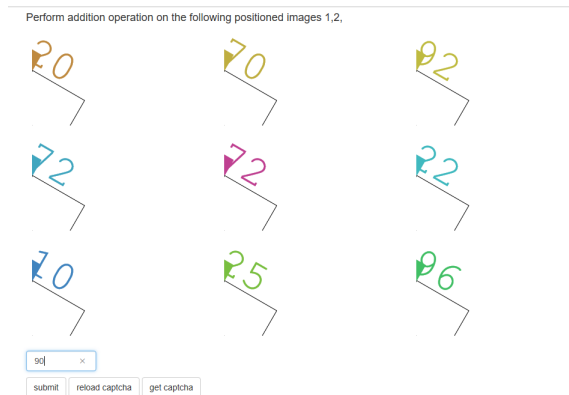
Enter Answer

submit reload captcha get captcha

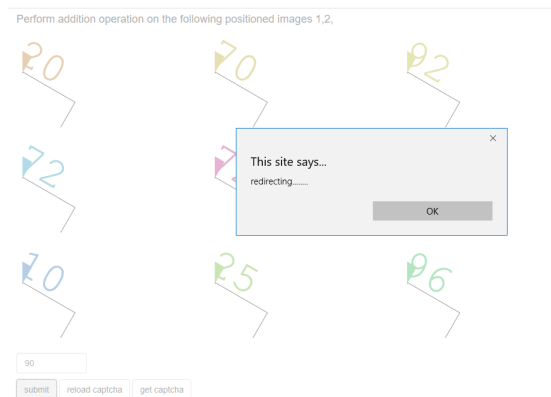
The above page is the home Screen of the CAPTCHA which has a question and three buttons along with a text box. The Canvas image is loaded when the get captcha button is clicked which is shown in the following Screen shot.



The Above screenshot displays a Canvas of 9 images composed of numbers. So, the arithmetic operation specified in the question is performed on those positions and Entered in the Text box as shown



The Arithmetic operation specified in question (addition) is performed on 1,2 positions and entered in the text box as 90 which is valid. So, if the entered value is correct it is directed to a designated page or if it is incorrect the Canvas images are reloaded which are displayed on get captcha button click shown as below.



If the Arithmetic operation done on those positions is wrong, then a pop-up is displayed saying that the Captcha is wrong.



## VI. CONCLUSION

As demonstrated above the project idea is to generate an image CAPTCHA based on Arithmetic operations. This CAPTCHA will try to avoid machine learning attacks due to its complexity and noise. Security is assured as this can only be solved by a human user. Here, the added noise and distortions will increase the complexity of the image based CAPTCHA. In this CAPTCHA, a button is used in addition which when enabled displays the Canvas of images. With this the time delay of brute force attacks can be increased such that the attacker cannot easily succeed in breaking the CAPTCHA. More over the number of attempts given by a user and the number of CAPTCHAs solved correctly gives the usability of the CAPTCHA which is a prime factor taken into consideration while developing a CAPTCHA. This form of CAPTCHA is more likely to be secure, robust against attackers and spammers as well as user friendly.

A further study needs to be done in Improving the complexity of AI-problems such as human cognitive skills to prevent bots. But, in this process even the human is finding it difficult to solve a CAPTCHA. So, further enhancements should be done in such a way that the tests are both efficient and user friendly

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