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REVIEW OF LITERATURE

NEED/IMPORTANCE OF THE STUDY

STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

RECOMMENDATIONS/SUGGESTIONS

CONCLUSIONS

SCOPE FOR FURTHER RESEARCH

ACKNOWLEDGMENTS

REFERENCES

APPENDIX/ANNEXURE

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- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
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- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–22 June.

**UNPUBLISHED DISSERTATIONS AND THESES**

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# THE JIGSAW CAPTCHA

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**ABSTRACT**

*In this paper a new CAPTCHA technique is proposed which focuses on dividing a picture into parts, jumble those parts and present them to the user (along with the original image). The user is required to assemble those parts in order to form the correct picture (the JIGSAW puzzle). This task requires judging the complex content of the broken parts of the image and making a decision as to which part is to placed where. The biggest advantage of the system is that the user will choose an image for the task from his own computer system and hence no database is required to be maintained by the website owner. The complexity of the system can be easily extended by dividing the image into as many parts as required. The system is very user friendly as most of us had played such a puzzle during our childhood days. Preliminary results showed that the users preferred this technique over usual text based CAPTCHAs.*

## KEYWORDS

CAPTCHA, bot security, web security.

## INTRODUCTION

According to J. Langford, L. Ahn and M.Blum(2004) CAPTCHA stands for "Completely Automated Public Turing Test to Tell Computers and Humans Apart". CAPTCHA systems have been widely adopted nowadays on the internet for protecting free online services for humans from abuse by automated scripts/bots. CAPTCHA must satisfy three basic properties. The tests must be

1. Easy for humans to pass
2. Easy for the tester machine to generate and grade.
3. Hard for a software to pass. The only automation that should be able to pass a CAPTCHA is the one generating the CAPTCHA.

CAPTCHAs are generally based on *Character* recognition or *Image* recognition. Although image based CAPTCHAs are more secure and hard to break but they are rarely used because they require a lot of database to be maintained.
But in my work I have proposed a technique which will overcome this drawback of image based CAPTCHAs

## REVIEW OF LITERATURE

A lot of CAPTCHA techniques based on images have been proposed so far.
M.Chew and J.Tygar (2004; 2005) presented two works on CAPTCHA. In their first work they proposed two techniques:

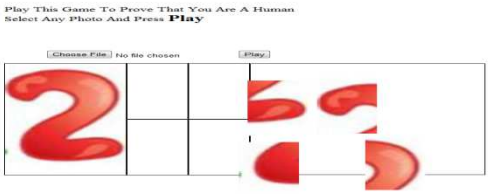
1. Asking the test subject to determine if two subsets of images are associated with the same word or not (the distinguishing CAPTCHA).
2. Showing the test subject a set of images where all but one image is associated with a word and asking the test subject to identify the anomalous image (the anomaly CAPTCHA).

In their second work called Collaborative filtering the CAPTHCA asks questions to the user that has no absolute answer. Instead the CAPTCHAs are graded by comparison to other people's answers. By observing real-world trends made by human subjects, collaborative filtering CAPTCHAs attempt to extract complex patterns that reflect human choices.
This technique suffers from problems like *misspelling, synonymy, polysemy and mislabeling*.
Another technique based on image orientation was proposed by R. Gossweiler, M.Kamvar and S.Baluja (2009). This CAPTCHA requires users to adjust randomly rotated images to their upright orientation.
D. Morrison, S. Marchand-Maillet and E. Bruno (2009) introduced a syatem called TagCAPTCHA which presents the user with a number of images that must be correctly labeled in order to pass the test. The images are divided into two subsets: a control or verification set for which annotations are known, and an unknown set for which no verified annotations exist. The verification set is used to control against the tags provided for the unknown set. If the user provides correct verification tags, the tags for the unknown set are promoted.
J. Elson, J. Douceur, J. Howell and J. Saul (2007) formally introduced Asirra (Asirra stands for Animal Species Image Recognition for Restricting Access"), a cat or dog labeling based CAPTCHA design. The beauty of Asirra lies on its cleverly using the database from Petfinder.com. It asks the user to pick images of "cat" among 12 random chosen pictures.
Y. Chanamolu (2009) in his thesis presents a method for implementing an image based CAPTCHA. The technique is based on image orientation in which some of the images presented to the user will be in correct position while some will be rotated. The user is required to select the rotated images. This method has two advantages as listed by the author. First since no exact labels are needed from the user, the class number of objects that can be used for orientation is theoretically infinite and can be huge in practice. The classes have no need to be static. Secondly as orientation is the focus, the image of objects can be repeatedly used as long as the object has not been identified. Image consumption can be much slower. But the images that are to be selected have to be such that their orientation should be unambiguous.

## PROBLEM DEFINITION

The contribution of my method is that it is an image based CAPTCHA. The images that will be used would not be required to be stored at the server side. In fact the image will be chosen by the user from the images that he/she has in his/her computer. Even if a user does not have any images he/she can still chose image from the clips that are already there in any computer that come as a part of windows operating system. The user will be required to choose any picture and then that picture will be broken into four parts and will be provided to the user in a jumbled fashion as shown in Figure 1. Also there will be a 2x2 matrix. The user will have to place the correct part into the correct cell of the matrix. When the user does this for all the parts he/she is directed to the next page.

**FIGURE 1: SAMPLE JIGSAW CAPTCHA**




As mentioned above one of the requirement for a good CAPTCHA is that it should be easy for the humans to solve. As this is one of the common puzzles that almost everyone goes through during his childhood, the users will find it very easy and interesting to solve.

## PROBLEM ANALYSIS

**IMAGE SELECTION**

The user can only select an image of extension *.jpeg, .gif or .png* only. This is done to avoid user selecting a file other than an image. A special check for the extension has been included to achieve this.

**PROBLEMS AFFECTING HUMAN PERFORMANCE**

Not providing image to the user from the server side saves a lot of space on the server but the user may encounter some problems while solving the puzzle that are related to making a good selection of the image for the puzzle. If the user selects an image like the one shown in Figure 2, it will take a lot of time for him to solve the puzzle because all the parts will be alike and the user will not be able to locate the correct location of the any sub part of the image.

**FIGURE 2: AMBIGUOUS IMAGE**

## USER STUDY

**CAPTCHA Metrics:** In this two metrics were considered for evaluating CAPTCHAs: a metric that allows us to measure CAPTCHA efficacy with respect to the number of matrix size and a metric measuring the expected time for a human user to take a CAPTCHA.

**Matrix Size**: As a the user can be provided with a number of options for the matrix size but it is to be considered that with increase in size of the matrix the difficulty level to solve the puzzle will increase and the user will be overburdened. The increase in size decreases the size of the each part of the sub-divided image and hence it becomes difficult for the user to identify the exact position of each part to solve the puzzle.

**Time**: Time is an important metrics for any CAPTCHA as a CAPTCHA is an overhead for any user. Hence the time to solve a CAPTCHA should be as small as possible so that the user spends more time on his/her intended work rather than proving his/her identity as a human being.

**ADVANTAGES**

1. The complexity and hence the security of the system can be easily increased by increasing the size of the matrix from 2x2 to any higher value like 3x3 or 4x4 or even higher as desired.
2. There is no need to store images on the server side and hence no need of any database.
3. The system is free from the problems faced in character recognition.
4. It is an enjoyable method as compared to traditional CAPTCHA.
5. The users who suffer from Dyslexia and hence face difficulty in solving character based CAPTCHA can easily solve this CAPTCHA.

## TESTS AND RESULTS

A test was performed in which about 84 users participated. Several goals were kept in mind for the test:

1. Average time taken by the users to solve the puzzle for various matrix sizes. Four matrix sizes were considered: 2x2, 2x3, 3x3 and 3x4.
2. Matrix size that the users would prefer to solve if this is provided as a CAPTCHA to them.
3. The enjoyment factor of this CAPTCHA as compared to the traditional character based CAPTCHAs.
4. The difficulty level of the CAPTCHA for various matrix sizes as compared to character based CAPTCHAs.
5. Any difficulty faced by the users.

The test was conducted on a web browser and the user response was taken in the form a feedback form. The results were as follows:

1. *Average time* taken (in seconds) to solve the CAPTCHA for various matrix sizes is summarized in the table below.

**TABLE 1: AVERAGE TIME TAKEN TO SOLVE CAPTCHA OF VARIOUS MATRIX SIZE**

| Average Time (in sec) | | | |
|---|---|---|---|
| 2x2 | 2x3 | 3x3 | 3x4 |
| 12.50 | 20.94 | 34.51 | 53.92 |

2. *Preferred matrix size*: 44% of the users preferred 3x3 matrix size for the test.
3. *Enjoyment factor*: Results showed that 82% of the users found this CAPTCHA enjoyable as compared to the traditional character based CAPTCHAs.
4. *Difficulty level*: The difficulty level was also compared to the character based CAPTCHAs. Difficulty was checked for each 2x2, 2x3, 3x3 and 3x4 matrix sized puzzle. Results showed that for 2x2 matrix 93% , for 2x3 65%, for 3x3 42% and for 3x4 36% users found it easy to solve as compared to traditional CAPTCHA.

## PROBLEMS FACED BY USERS

The main problem that some of the users encountered was that when the matrix size increases the broken parts become a little small and hence the users find it difficult to place the right part in the right location.

Another problem reported by a few users was that if the image had a white portion and that white portion becomes one of the broken part of the image then it becomes difficult to find that white part and hence to solve the puzzle. Hence even after placing all the parts correctly the user will not be able to pass the test because he would not come to know that the white part is not still placed in its correct location.

## CONCLUSION

A novel CAPTCHA system is presented that requires the users to correctly drag and drop the broken parts of an image into their correct location. This is a task that many users are already familiar with. Initial results showed that 82% of the users found this method to be more interesting and enjoyable to deciphering text as is required in traditional CAPTCHA. Results also showed that for simple lower matrix size like 2x2 and 2x3 the users found this method to be easy to solve than deciphering text as is required in traditional CAPTCHA. Also as the difficulty level is increased i.e. matrix size is increased, it requires more time to solve the CAPTCHA.

Also as no image database is required for this system, the party implementing this system is free from the overhead and cost of maintaining a huge database. Some users did encounter some difficulty in solving the puzzle for matrix of higher size but overall the response time was very satisfactory.

## SCOPE OF FURTHER RESEARCH

There are a number of interesting extensions to this CAPTCHA system that we can investigate and deploy. This system does not work if it is accessed via mobile. The user is not able to drag the broken parts into their desired location. Hence the task can be implementing this system for mobile phone users also.

Another aspect is to look into the security of the system. The system can be tested for possible ways of bypassing it. So far I did not come across a method or technique in artificial intelligence that could solve this puzzle by its own. Hence a study can be done to find out the possible weak points of the system and hence to overcome them and make the system more secure.

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