Analysis of Semantic Gap Using Entropy and Usability Factors of Image Based CAPTCHAs

A Dissertation Proposal submitted

By

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To

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In Fulfillment of the Requirement for the Award of the Degree of

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Under the guidance of

Ms. Usha Mittal

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PAC

ABSTRACT

Image Processing is an emerging research domain in every walk of data in our life. As a part, image retrieval and its analysis have its significance in identifying and measuring different factors in different images. In this research work, we have proposed the methodology to measure the semantic gap factors in different image based CAPTCHAs to define relation between usability issues and semantic gap. Different techniques have been literature reviewed in which a number of methods for measuring the semantic gap has been proposed. For evaluation different image based CAPTCHAs are considered to deal with. We shall also provide a designing factor requirement for the CAPTCHA designers as the prime objective of CAPTCHA includes robustness along with usability.

CERTIFICATE

This is to certify that **Gagan Deep Rana** has completed M. Tech Dissertation Proposal titled **"Analysis of Semantic Gap Using Entropy and Usability Factors of Image Based CAPTCHAs"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma.

The dissertation proposal is fit for the submission and the partial fulfillment of the condition for the award of M. Tech in Computer Science and Engineering.

Date: ----------

Ms. Usha Mittal (The Advisor)

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DECLARATION

I hereby declare that the dissertation proposal entitled, "**Analysis of Semantic Gap Using Entropy and Usability Factors Image Based CAPTCHAs**" submitted for the M. Tech Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date:

Investigator

Regd. No.

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Lastly, I offer my regards to all of those who supported me in any respect during the completion of the dissertation proposal report.

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Chapter 1
INTRODUCTION

Everyday huge amount of images are generated through different source such as cameras, medical imaging, space mission, scientific reactions, forensic, satellites and entertainment industries. Image is a good medium of capturing and delivering information visually. It can represent facts in much effective way than documents. They visually represent facts and things. Elements, objects and things in images are identifiable even if quality is not good or some of the data may get corrupted during the transmission. Images captured by spacecraft are useful to learn about the presence of elements, forming particles, structure and other useful information of the planet. It may happen that quality of image sent by spacecraft is not so good for analysis due to the loss of data in transmission. It can be restored by using different image processing techniques to achieve a better quality of image for analysis. Scientists extract information from processed images with different point of views as they require. Spacecraft images also used for observation purpose of planets, stars or other space activities. In scientific reactions hundreds of images are captured during the reaction. After successful completion of reactions images analyzed to identify the phenomenon occurred during the reactions as the chemical reactions are so fast and difficult for human experts to understand during the progression. To extract useful information from these huge amount of images generated during the reaction image processing is needed for handling and retrieval process. Some of images may get distorted or visual information is not identifiable then image processing plays a vital role in restoring the image for better results. In medical field, images play vital role in diagnosing diseases and abnormalities. Imaging techniques such as X-ray, magnetic resonance imaging MRI, computed tomography (CT) Scans lets doctor to see inside human body to take images of bones, nerves, organs and cartilage. This is how images help doctor to determine any type of abnormality and narrow down. Medical images generated by different techniques such as X-ray, CT Scans, MRI have different properties so needs different image processing techniques for handling and retrieving information useful to doctor to narrow down abnormalities. Past decade made tremendous enhancements in technology that make technology easily available for everyone on this

planet. Every day huge amount of images captured by digital camera and cell phone camera uploaded to social media sites and shared among peoples. These vigorously shared images need image processing techniques for storing and searching process to achieve performance and transmission at lower cost. Business sites use images for advertisement, promotion and displaying product on portal attract consumer. Better quality of image required to represent product attractive at low cost and high performance can be achieve with image processing.

Any operation such as compress, crop, segmentation, blur, sharp etc. performed on image is image processing. For each operation there are many algorithms proposed by pioneer researchers. In other words image processing is the study of any algorithm which takes image and returns a vector matrix as output. To digitize historic pictures, paintings and manuscript image processing plays a vital role in this process of digitization. For storing, managing and indexing in image database image processing needed. Image databases growing vigorously as everyday huge images are generated from different sources discussed earlier. At this point of time searching of an appropriate image comes into picture. Someone looking for pictures of its own or family member in database, space researcher searching for image that closely match to a recent event happen in space for comparative study and looking for outcomes, someone searching his or her favorite film stars, actors and actresses images. It's not possible that people always face camera, they may standing sidewise or their half of face may be out of picture. Events occurred in space never be identical. Abnormalities in human body may be at different stages when captures through imaging techniques. Image processing provides algorithms for finding closest match to required set of images. So there is a severe need of efficient and effective techniques for the searching and retrieval of images. Many techniques have been given in literature for searching and retrieval of images some of those shown marginal improvement. Image retrieval is a crucial phase for any image retrieval system. There are mainly two methods used for searching and retrieving images namely: Text Based Image retrieval and Content Based image retrieval. Text based image retrieval is proposed in 1970s based on annotation, tags, title and other text information attached to image, manually supplied by the user. Some techniques were developed to automatically annotate image. It's impossible to annotate big image databases manually and also the automatic annotation techniques are not much efficient to annotate image with effective tags. Automatic text annotation techniques based on bottom-up approach. To overcome

this problem Content Based Image Retrieval (CBIR) technique is proposed in 1980s based on one or more features of image such as texture, color, shape and combination of texture-color etc. In CBIR an example image is supplied and features are extracted then extracted features are compared with image feature vector of database images. Based on similarities, images are retrieved to user. CBIR techniques had shown greater impact on image search and retrieval. Sometimes images retrieved by retrieval system do not meet with human desire due to the rich semantic of human. This gap between the humans' perception and the computer's computation is known as Semantic Gap term coined in 2000. Many techniques have been presented to narrow down or bridge the semantic gap between humans' perception and computer's computation. Merging of Text Based Techniques and Content based techniques has shown good results. Further research work is going on to quantify and measure semantic gap to evaluate the efficiency of proposed techniques for reducing the semantic gap but still efficiency and effectiveness is lacking in image retrieval systems.

1.1 Text Based Image retrieval

Text based image retrieval is widely used by image searching systems such as Google image search, flickr and Bing. Results are fetched on the basis of keywords supplied by the user. Text Based Image Retrieval is totally based on the image tags and annotations done by human labor, but it's very tedious task to annotate each and every image with text and also it's impossible to supply exact text description of image. Different people have different perspective for a single image. An image has much richer content than a query supplied by the user. For same image different users use different keywords according to their perception, this will cause a semantic gap problem that we are going to discuss in later part. Sometimes user has a specific concept in mind but cannot express that with words in query and user does not get appropriate results as per the concept in users' mind.

1.2 Content Based Image Retrieval

To bridge semantic gap, content based image technique is proposed. Visual features such as texture, color and shape of images are extracted and categorized. Low level features of image cannot specify the high level semantic of user's mind e.g. search image of a baby kid. Semantic gap problem also reported here. Even query image provided by the user not

always specify concept that user have in mind. Retrieval system returns results as chair, ball and blanket, because these thing also present in image supplied by user as query image to retrieval system. In Content Based Image retrieval an example image or a query image is provide to system first and based on that image features a feature vector is generated and then features are compared with feature vector of stored database images, and after clustering, classification and re-ranking the most similar images are retrieved. The feature vector is based on low level features of image such as color, texture and shape etc. by using techniques presented by various authors in literature.

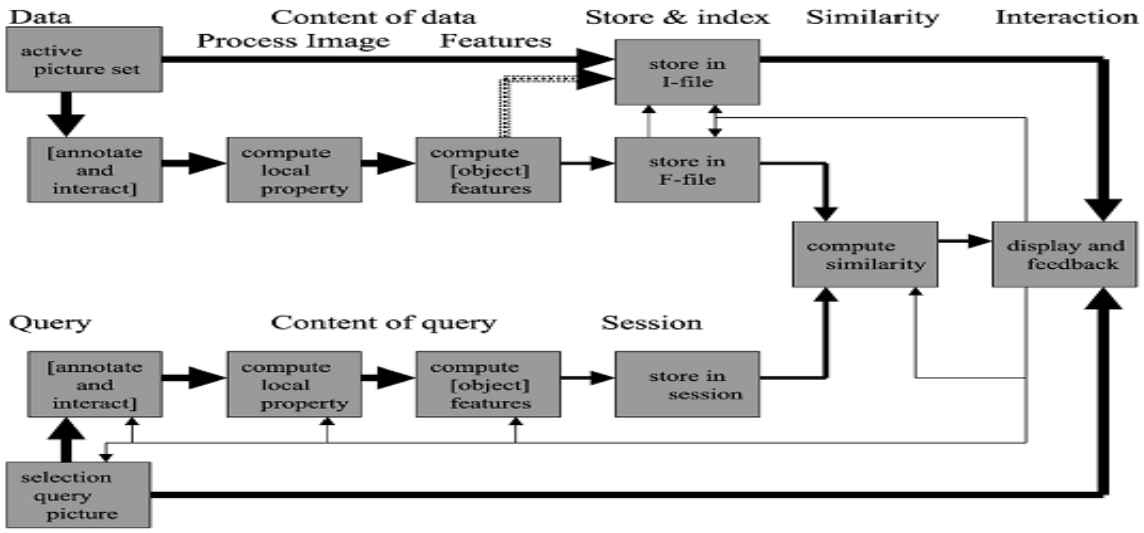


Figure 1.1: Framework of Content Based Image Retrieval [15]

1.3 Semantic Gap

Semantic gap problem is reported in both Text Based Image Retrieval and Content Based Image search techniques. Lack of correlation between the semantic categories that a user requires and the low level feature that CBIR system offer [4]. Various methods are proposed to narrow down or bridge this gap. Proposed algorithms have marginal improvement but still efficient algorithms to be design to avoid semantic gap. Text based and visual content based techniques are used together to address this problem. Still some issues are unsolved there. No significant method is there to measure proposed algorithms' efficiency. The present techniques are only focused to narrowing down the gap and bridging this gap. No significant method is for quantifying and measuring the semantic gap exited there in the users' perception and result retrieved. In next chapter we will discuss about the techniques proposed for solving this problem.

1.4 CAPTCHA

Completely Automated Public Turing Test to Tell Computers and Humans Apart simply known as CAPTCHA a technique proposed to automatically distinguish between human and computer program so called bot. CAPTCHAs provide mechanism to stop bot programs to create unnecessary load on server. There are different types of CAPTCHAs based on text, image, video, sound and puzzle. In text based CAPTCHAs characters, numbers and symbols are distorted by adding lines or blurring so that it become difficult for bot to recognize the characters but humans can still identify these characters. In image based CAPTCHAs user has to choose semantically similar images to pass the test. In video based CAPTCHAs, a video is shown to user. And in puzzle based CAPTCHAs user has to solve a puzzle to arrange the tiles or solve and mathematical equation. But sometimes it become difficult for the humans to recognize CAPTCHAs correctly due to the disabilities or may be the high complexity of CAPTCHAs that became hard for human to understand. CAPTCHAs are for securing system from malicious bots but it must be easy for users to understand. User must be capable of to solve CAPTCHAs in reasonable time either it will be very irritating for user.

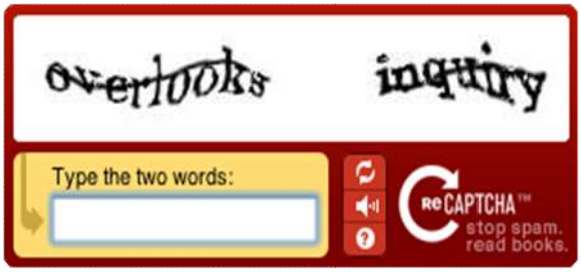


Figure 1.2: reCAPTCHA[11]

Figure 1.3: Combo CAPTCHA [11]

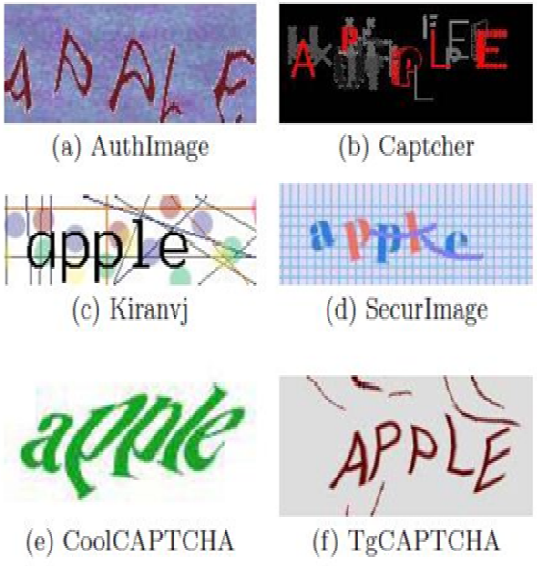


Figure 1.4: Text Based CAPTCHAs [11]

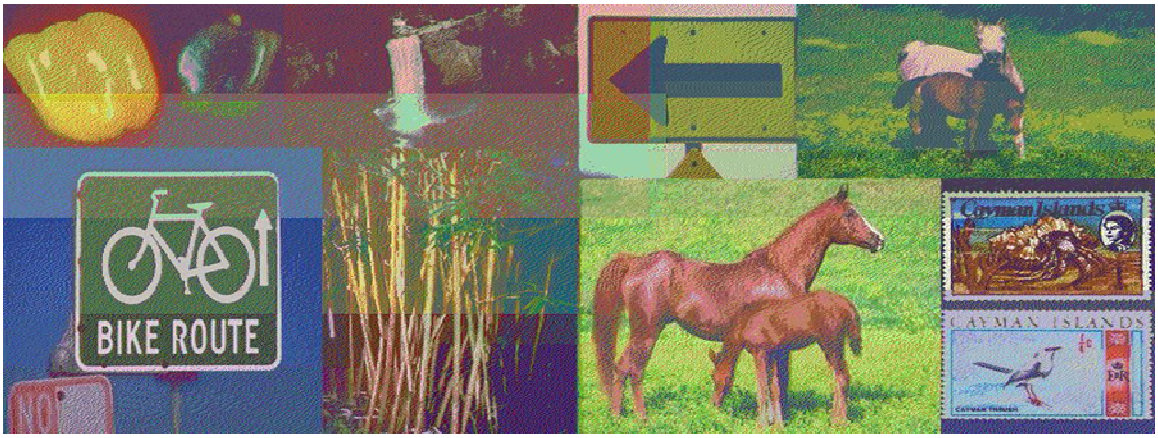


Figure 1.5: Geometric Center CAPTCHA [11]

Table 1.1: Comparison between TBIR and CBIR

	TBIR	**CBIR**
Content	Image	Text, Number
Factor	Color, Shape, Texture	orientation, angle, size
Techniques	Color Histogram, Dominant Color, BOVW, Fourier Transform	Boolean Search, Vector Space Model, BOW, Stemming

Chapter 2
LITRATURE REVIEW

Various generative models, discriminative model, supervised learning, unsupervised learning based model have been presented to narrow down semantic gap or bridge this gap.

In the paper [1], the authors M. Venkat Dass and et al. had proposed an interactive genetic algorithm to improve image retrieval system's accuracy. Proposed method is based on genetic algorithm. They had taken color, texture and edge features for their model and interactive genetic algorithm for users' intension. They used HSV color space because of its closeness to human perception and grey level co-occurrence matrix for texture representation. They measured image complexity using entropy as high entropy means complex texture. For edge representation they used histogram, they found that humans' vision system is sensitive to edge feature. They introduced a fitness function to original genetic algorithm which evaluates fitness as per the users' perception. Experiment results found that interactive genetic algorithm (IGA) performed well as compare to other similarity approaches.

In the paper [2], the authors Eugene Santos Jr. and Qi Gu had proposed a method to improve relevancy rate in searches based on text to image re-ranking approach. They introduced a concept detection method and automatic relationship detection method to fill the semantic gap between textual queries and visual features. High level concepts mapped to query by semantic analysis, then image is related with concept content. Based on color and homogeneous texture information image is segmented into several regions, each concept is annotated. For the identification of relationship between query and concept they introduced a two level scoring system based on re-ranking classification of content that close to semantic concept, they used high level semantic analysis first and then classified on content i.e. low level content. Authors defined concept as integration of both textual and visual features, each concept has image and text description, they introduced an automatic method to supply textual description based on some trusted references. They introduced an automatic semantic scheme (SMS) to identify semantic related concept between query and semantic classes. Relevancy of retrieved images related to query when

image matches both semantic concept and content wise. They loosen limits for relevant information, so that query having less relevant information can perform well. Authors introduced dynamic database concept to handle user query variations and to reduce human labor for building initial concept database. In experiment they found better results and also found that initial automatic concept building method not performing well and to initialize concept database automation needs improvement. Main motive of this proposed approach is to retrieve relevant images through text query by relating query concept to semantic concept in concept database with low level features related to high level features.

In the paper [3], the authors Mohsen Sardari Zarchi and et al. had proposed a semantic-based model for efficient image retrieval taking user as essential component of system. They proposed algorithm for image segmentation of user desired region. They found that region selected by user will help to bridge semantic gap and will increase efficiency and performance as only rich user desired information is supplied to system and easy to identify objects in that region. They also found that only selecting region is not enough as still the semantic is not clear, so they derived a relation between objects in region by ontology theory and found the semantic. They used a modified maximal similarity based region merging (MSRM) has ability to extract multiple objects. Author's extracted basic features color texture and shape after extracting objects from region. They extracted color with HSV space because of its closeness to human perception, color moments because moments are used to identify distribution of color and color based content. Color histogram represents frequency of color distribution, color coherence vector (CCV) is used to overcome spatial information that color histograms lack. For texture extraction they used wavelet transform because closeness to human vision and co-occurrence matrices to measure texture. They used region based and contour based shape extraction technique along with area, circulatory, eccentricity and Zernike moment. Authors found ant colony optimization (ACO) algorithm best for feature selection and constructed robust and efficient feature vector. Authors used artificial neural network (ANN) to recognize image object. For similarity measure purpose authors used ontology structure to represent query image and using ANN image objects are recognized, then the retrieved images are re-ranked based on similarity with query image. In experiment results proposed model shown reduced time complexity, improved performance of classifier.

In the paper [4], the authors Reza Bahmanyar and Mihai Datcu had proposed a communication channel based method to quantify and measure semantic gap. Information carried by low level feature descriptors is quantified by communication channel using information theory. Mutual information of given image and provided result is considered as quantity of information. They used Latent Dirichlet Allocation (LDA) a generative probabilistic model which automatically discovers hidden image structure for semantic annotation purpose. Authors introduced a method for distance measurement between users' and computers' semantic; classes were represented by computer discovered semantic topics. Authors found that the distance between users' and computers semantic is the semantic gap. Author found relation between mutual information and semantic gap as the mutual information increases semantic gap decreases. In experiments results found that each feature carries particular amount of information, increase in mutual information will decrease semantic gap which leads to closeness of users' semantic to computers' semantic.

In the paper [5], the authors Hassan Farsi, Sajad Mohamadzadeh proposed a Hadamard matrix and discrete wavelet transform based techniques in hue-min-max -difference color space for accurate image retrieval. Before the extraction of features they resized all images and then applied HDWT to construct feature vector of dataset and query for the computation purpose. Authors found that proposed technique had shown better performance in comparison of various other exiting techniques.

In the paper [6], the authors Guang-Hai Liu and Jing-Yu Yang had proposed a method for image feature representation based on named color difference histogram. Authors found that previously presented methods did not represent L*a*b* needs improvement to be used in content based image retrieval, to address this problem they proposed color image analysis algorithm color difference histogram. Proposed algorithm combines features of color, edge orientation and perceptually uniform color difference without any segmentation, clustering and model training. Authors found that human visual system is very sensitive towards color and edge orientation and rich visual information variety is contained by perceptually uniform color difference between color and edge orientations and this information is very helpful for content analysis of image. Authors proposed a combined descriptor for orientation, color and color difference without learning process and segmenting the image. They found that L*a*b* had high uniformity with human color perception, and edge orientation plays big role in human image perception and they

found that color quantization is closely related to color space. As human image perception is closely related to edge orientation, color and uniform color difference and its challenging to represent all features as whole. In experiment they found the proposed algorithm much efficient and closer to human perception and taken as an improvement to multi-texton histogram and also found that algorithm have much discriminating power of spatial layout, texture, shape feature and color.

In the paper [7], the authors Jing Liu and et al. had proposed a method sparse semantic metric learning (SSML) extracted knowledge from tags, annotation supplied in social media for image to learn semantic metric to improve search results. They found that most of the retrieval systems do not meet user's requirement and also performance and efficiency issues are there. Authors employed three principles for the formulation of problem by retaining visual and textual space similarity consistency, keeping noisy, incomplete and personal tags in control and remove noisy, redundant features from original space. They introduced constraints for learning metric to remove noisy features. They introduced an iterative algorithm for optimization. For problem formulation the given a function to measure disagreement between the heterogeneous spaces. For reduction of semantic gap they suggested pair wise similarity preservation of mapping space and textual space. They introduced iterative algorithm for optimization problem have a proved convergence. In experimental results they had found that proposed method have better performance than other method and enhancements can be introduced by employing search-based tags for refining results. In conclusion they found user supplied tag in social media effective to reduce semantic gap and enhance performance.

In the paper [8], the authors Zhixin Li and et al. had proposed a hybrid approach for automatic image semantic learning. The proposed approach is based on continuous probabilistic latent semantic analysis approach through generative learning. They found semantic concepts detected by generative learning model correlate visual feature and textural words. Experimental results shown high accuracy and effectiveness as compare to many other state-of-the-art approaches. Authors found that this approach can be effective in data mining and reorganization after some adoptions.

In the paper [9], the authors Xianwang Wang and et al. had proposed content based image retrieval with unsupervised attribute learning. Unsupervised bag-of-visual-words model based content based image retrieval approach is proposed for clustering and classification.

And then they proposed a re-ranking algorithm for searching. They found that attributes have more semantic meaning than low-level features. The primary goal of researchers is to retrieve images of same person wearing same dress as person in different poses doing different task. To form codebook using bag-of-Visual-Word approach they used color patches because high discriminate power. To get the intent of user they used attribute learning classifiers. They first retrieved result from color matching and then learned attribute re-ranking algorithm used to refine results. Proposed method tested against a public dataset containing 1008 images and they found that proposed color based descriptor alone achieved significant results and found proposed re-ranking algorithm have improved results. Proposed method showed improved retrieval performance on clothing images taken in different conditions. Further authors found that feature selection can remove redundancies when combined.

In the paper [10], the authors XIE Xia-qing and et al. had proposed a semantic based image retrieval model. They color, texture and shape features to form vector matrix. They extracted color HSV model as this model is more closer to visual perception of humans, texture through co-occurrence matrix because texture have important information and shape through moment invariant as shape is independent of color and texture respectively separately, then they normalized each vector and calculated values. Similarity of features is measured by Euclidean distance. K-nearest neighbor (KNN) is used for vector training to the semantic gap. Experiment shown good results and they found that bigger training set will give high precision. They suggested distributes system for training image for too long response time taken by system.

In the paper [11], the authors Rahul Saha and et al. had shown a gamification approach to analyze different usability factors related with different image based CAPTCHAs like negative CAPTCHA, geometric centre CAPTCHA, combo CAPTCHA, Assira, Claptcha. Their analysis have drawn a conclusion for the CAPTCHA designers to calculate different factors of images to design the image puzzles in a better way which can provide a usable way to gain access over a service with less complexity and more robustness.

In the paper [12], the author Mohammed Belkhatir had proposed an improved three levels of image representation namely Signal, object and semantic. First level i.e. Signal level abstraction represents color, texture features in mathematical terms. Second level i.e. Image Object level represents labels for image based on the signal level representation of

images, different semantic categories have specifics visual words. Third level i.e. semantic level is used to represent explicit characteristics of image objects found in second level, different semantic categories may have some additional visual representation. Authors introduced improvements in all three levels. They established a relationship between low level feature and high level semantic in signal level. They introduced a statistical model for automatic object based indexing in object level. In semantic level they introduced a unified model to improve image description by coupling signal level and object level based on logic based knowledge formalization. They had evaluated their work with corpus of consumer photograph and the TRECVid corpus of image frames extracted from news videos mainly. They found that results are poor obtained by compared system in TRECVid experiment and can be improved further.

In the paper [13], the authors Chengjun Liu and Guangwei Song had proposed a method to quantify information and measure semantic gap. They shown relation between text based image retrieval and content based image retrieval and then they come up with a user centered definition of semantic gap defined as the semantic gap is actually a dynamic user- desired gap. The user inputs certain information/images with user-knowledge; the computer then outputs the setting results/images through the computer-intelligence method. But when the results/images don't reach the user's expectation then the desires gap occurs. They evaluated features using ontology theory divided features into: color, shape, position, size and then measured entropy of image to quantify information using information theory. From quantified information they come up with method to measure the semantic gap. In conclusion they discussed the areas where deeper research needed for stronger measuring method.

In the paper [14], the authors Najlae Idrissi and et al. had used intrinsic properties of co-occurrence matrices with some degree of tolerance to interpret texture semantics. Co-occurrence properties related to s perceptual textural features as semantic meaning for low level features of texture. They had given inference rules to interpret co-occurrence features. They found improved result for semantic classification with respect unsupervised k-means algorithm. For semantic gap bridging test they used Galois lattices and found that when database size increases system performances slows down, they achieved marginal results. They also found that it's not possible to give single interpretation for texture so fuzzy logic will work fine to give different textural interpretations.

In the paper [15], the authors Smeulders et al. had given a framework for image retrieval based on study of existing system facing various problems and effecting content based image retrieval process. They found number of problems in literature to address such as semantic gap, sensory gap, image format and pattern of use etc. In conclusion they discussed about the crucial components of the retrieval system, problems faced by the systems and supplied solution for mitigation and removal.

Chapter 3
SCOPE

CAPTCHAs are image based technology used for access control of the internet services. Different CAPTCHAs can be seen in different applications. For example, PNB online banking provides an image based CAPTCHA. Even Facebook, Gmail and all the other commercial sites use the same technology to avoid Bots attacks. CAPTCHA designing is an emerging trend for internet services. Along with that, CAPTCHAs some time provide enough complexity to get a service to be accessed. Previous authors [11] have already analyzed different complexity and usability factors for designing a CAPTCHA. But still, there is a missing link as they have not considered the semantic gap of such image CAPTCHAs. Our analysis will help the CAPTCHA designs to bridge the semantic gap and to make it more usable as per different usability factors and complexity issues. Different applications then can apply the CAPTCHAs images according to their need and severity of access procedure. New framework (model) will be proposed for the designing of CAPTCHAs.

Chapter 4
OBJECTIVE OF THE STUDY

Today's technology deals with a huge number of images containing some useful information. Those images need to be processed so that proper information can be retrieved from them. Therefore we have taken image information retrieval as part of research work.

Images can only be properly retrieved if it does not have any gap between their representation and interpretation. Thus, the semantic gap provides a useful factor for such information needed to be retrieved from images. Semantic gap analysis is therefore our interest of work.

During the literature review so far, we have found concepts of CAPTCHAs which have been used intensively in different internet services. Once you solve the CAPTCHA puzzle, you can get access the service, if you are not able to do chances are there for a limited time after which service is temporarily unavailable for your access. For such CAPTCHA technology, semantic gap is a concern for designing puzzles because if semantic gap is more, the puzzles will be harder and nobody can access the service solving those puzzles. As a result, it will lead to loss of resources. Therefore, our problem statement deals with semantic gap analysis of image based CAPTCHAs to define usability.

The prime objectives of our proposed research problem can be summarized as below.

1. To study and analyze the various techniques for image retrieval and methods for measuring the semantic gap in images.
2. To analyze the semantic gap among different image based CAPTCHAs.
3. To model and design an algorithm based on content based image retrieval to measure and reduce the semantic gap of image CAPTCHAs.

Chapter 5
RESEARCH METHODOLOGY

This research is descriptive research based on analysis of the existing techniques of semantic gap measurement, implementing the techniques on image based CAPTCHAs and defining a relation between usability and semantic gap. The research will be depending upon both the primary data and the secondary data. The primary data will be collected from the experimental analysis of semantic gap measurement. The secondary data will be collected as usability factors from the secondary data source as literature review. Both the data will help us to analyze the strength and weakness of the techniques.

To achieve the objectives of this study, lot of literature survey has already been done. More literature review will be needed to get more concepts and constructs. Further we shall follow the following steps for our proposed research problem.

Step 1: Implementation of semantic gap measuring algorithms on image based CAPTCHAs considered in the literature review.

Step 2: Variation of different usability factors rating as per the literature review.

Step 3: Generating correlation between semantic gap and usability factors.

Step 4: Validity of relation with different variations.

Step 5: Generation of Semantic gap analysis model

Step 6: Output representation.

The overall flowchart of our proposed research has been shown in next page.

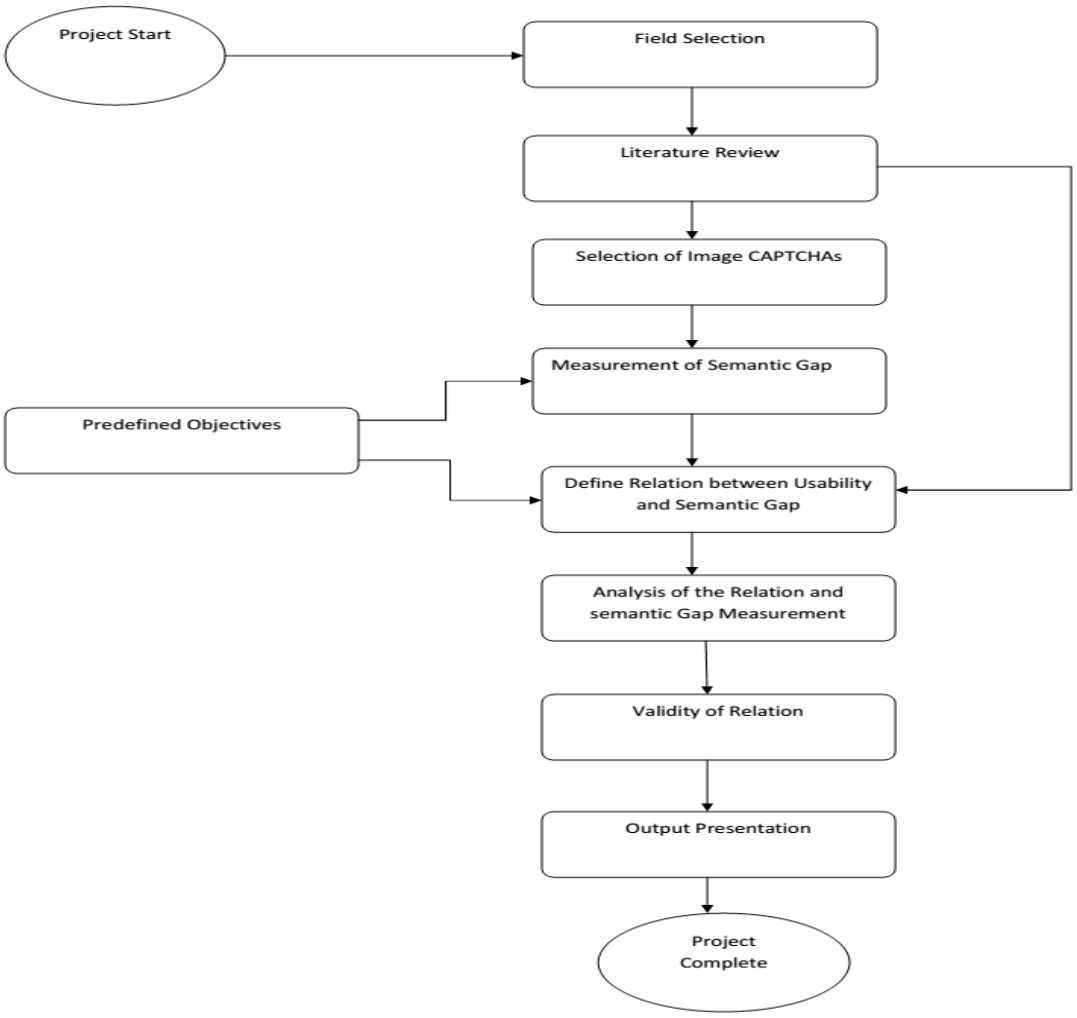


Figure 5.1: Flow Chart

5.1 MATLAB

Matrix laboratory popularly known as MATLAB developed by MathWorks is a high-level programming language with rich features to program applications, analysis and represent output in an interactive way [17]. MATLAB provides various inbuilt implemented mathematical formulas from various domains of engineering, banking, bioinformatics and medical science etc. for direct use. MATLAB provides separate toolbox for image processing and computer vision with implemented algorithms and plenty of functions. Image processing toolbox provides various image transformation functions such as filtering, blurring, segmentation, enhancement and features analysis [18]. Image Processing Toolbox is compatible with wide variety of images generated by different technologies such as digital cameras, telescopes, smart phones, scientific instruments, sensors, microscopes etc. and this tools box also supports a number of standard file formats of image. Various inbuilt apps enables user to manipulate image to

discover interesting features and explore the richness of image features. MATLAB provides flexibility to generate C, C++ code directly by using MATLAB Coder toolbox. MATLAB also provides flexibility to write program faster than traditional languages as there is no need to declare variables, assign data types and allocate memory. Algorithms can also be developed faster in MATLAB. MATLAB provides most of features from traditional languages such as object oriented programming (OOP), flow control and error handling etc. One can develop complex programs by using inbuilt algorithm of MATLAB with newly developed algorithm.

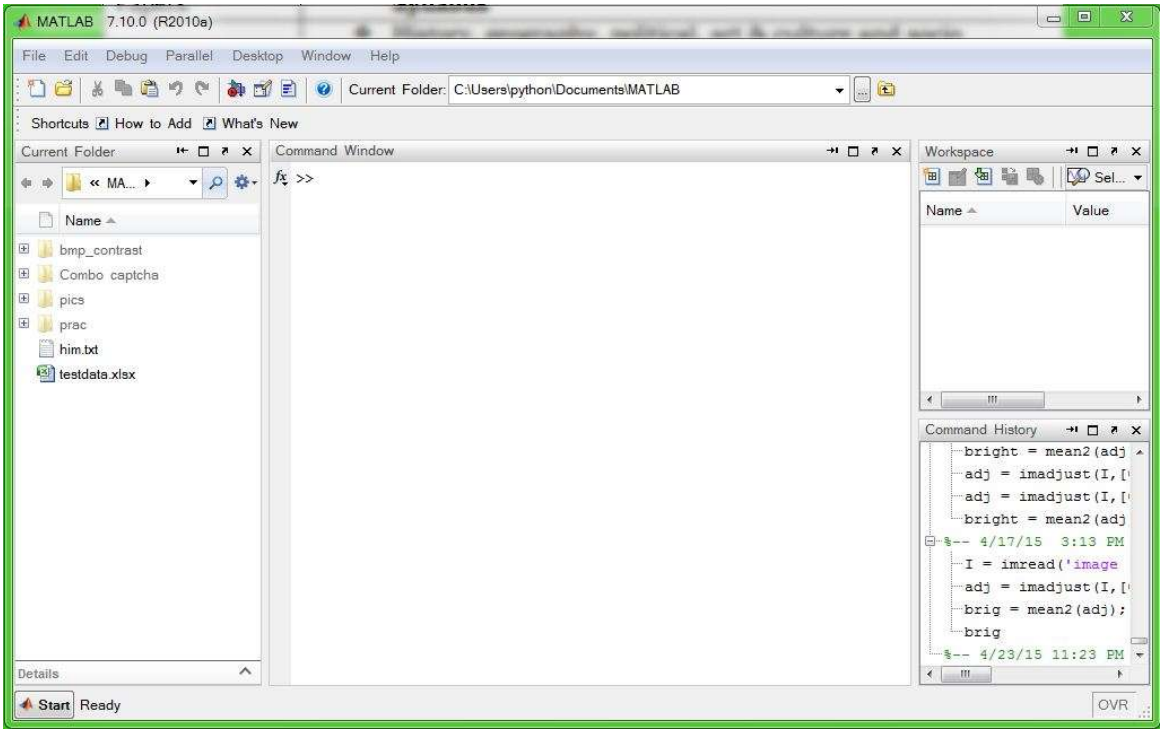


Figure 5.2: MATLAB Interface

5.2 Components of MATLAB

Command Window – lets user to interactively enter commands, execute commands and display results.

MATLAB – lets user to edit individual lines of code and debug

Code Analyzer – to maximize maintainability and performance code analyze automatically checks for problems and suggest modifications

MATLAB Profiler - checks for area of code needs modification for improvement and measures performance of MATLAB programs

SPSS

SPSS [19] stands for Statistical Package for the Social Sciences originally developed by SPSS Inc. acquired by IBM in 2009. SPSS Statistics is a powerful tool with analytical techniques and time-saving capabilities to gain deeper insights in data, discover hidden relationships and trends. SPSS is capable of handling big amount of data and can perform all kind of analysis. SPSS can be used to create tables and graphs.

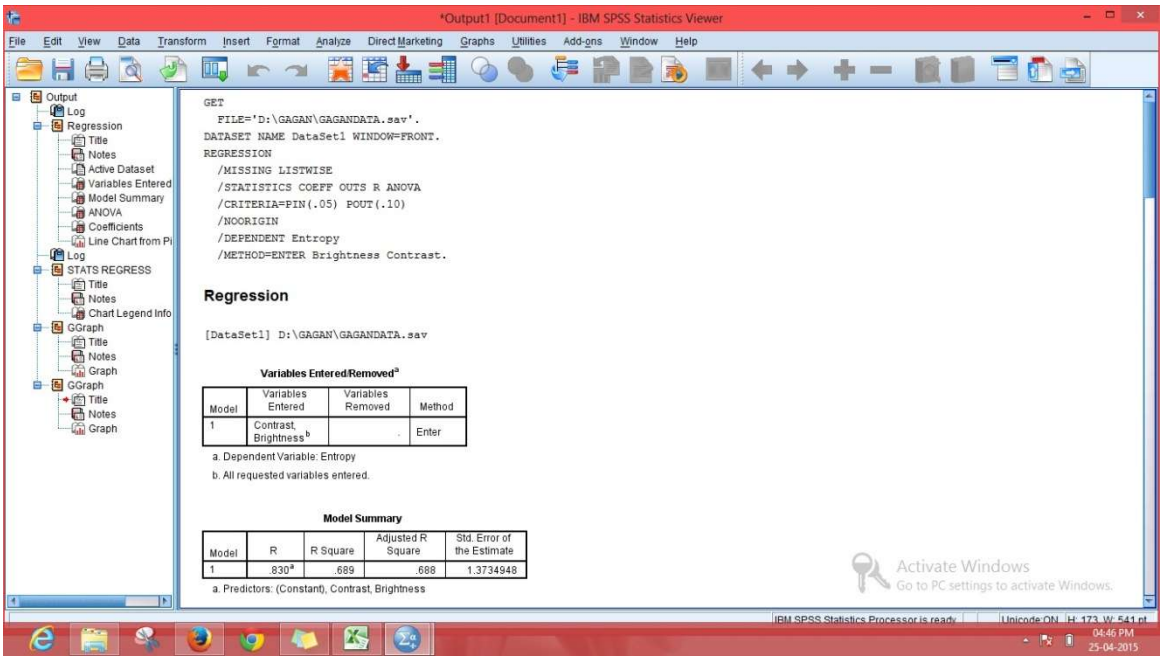


Figure 5.3: SPSS Interface

Chapter 6
IMPLEMENTATION

6.1 Sources of Data

Different kind of CAPTCHA images are collected for implementation of proposed work:

- Negative CAPTCHA images
- Geometric Centered CAPTCHA images
- CLAPTCHA CAPTCHA images
- Combo CAPTCHA images

Figure 6.1: CLAPTCHA [11]

Figure 6.2: Negative CAPTCHA [11]

Figure 6.3: Combo CAPTCHA [11]

6.2 Entropy

Entropy [20] of image is the amount of information that an image contains. Flat images have entropy zero and image containing heavy objects have high entropy value.

Formula for calculating image entropy

$$Entropy = -\Sigma_i P_i \log_2 P_i$$

$$P_i \text{ is the probability between two adjacent pixel difference is } i.$$

6.3 Brightness

Brightness [23] of an image is the average over all pixel intensities. Brightness can be taken as arithmetic mean of red blue and green coordinates.

$$\mu = \frac{R + G + B}{3}$$

6.4 Contrast

Contrast [21] is the amount of difference between color and brightness to which different objects in the image can be visually distinguished from one another. Root Mean Square (RMS) Contrast is the standard deviation of the pixel intensities.

$$\sqrt{\frac{1}{MN}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left(I_{ij} - I'\right)}$$

Where M N is the size of two dimension image,

And I_{ij} is the i-th and j-th element intensity, I' is the average intensity of all pixel values.

6.5 MATLAB

Following are the steps to calculate brightness, contrast and entropy of image in MATLAB.

Load image to workspace

$$I = imread('ImageName.jpg');$$

Adjust brightness and contrast

$$Adj = imadjust(I, [0\ 1], [0\ 1]);$$

Calculate brightness values as

$$Bright = mean2(adj);$$

$Mean2\ is\ an\ in-built\ function\ for\ calculating\ mean\ of\ image\ intensity\ values.$

Calculate contrast value as

$$Cntrst = sqrt(mean2(adj.\hat{}2));$$

Calculate entropy value as

$$E = entropy(Adj);$$

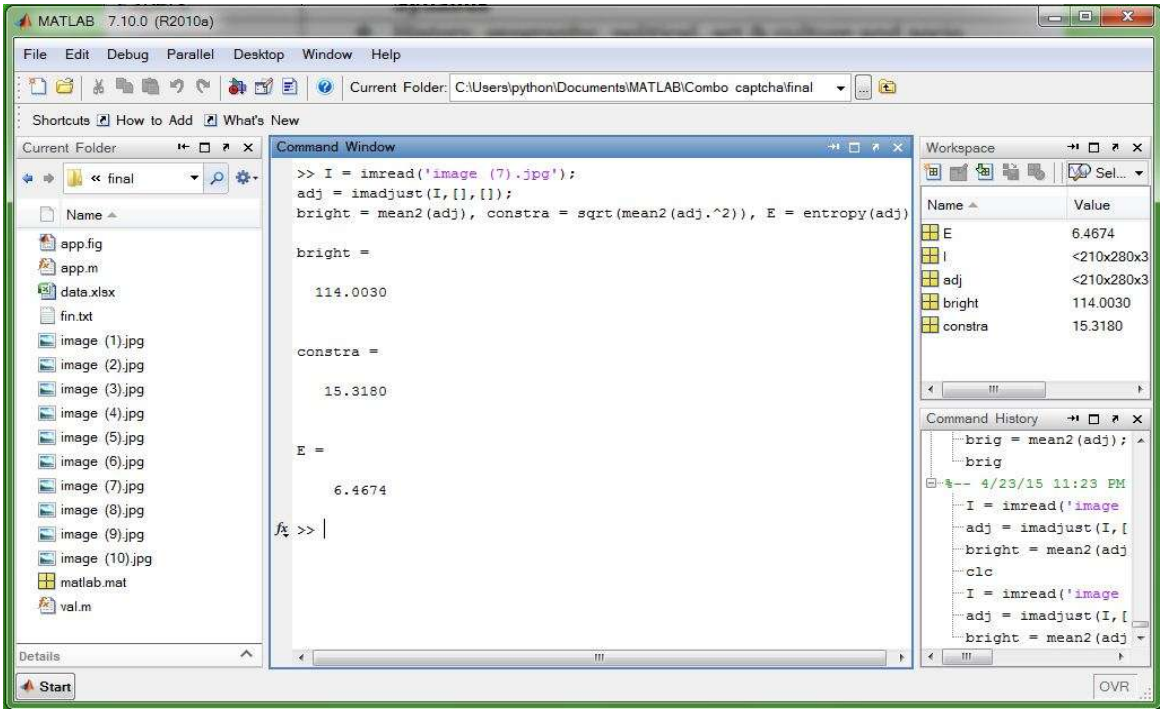
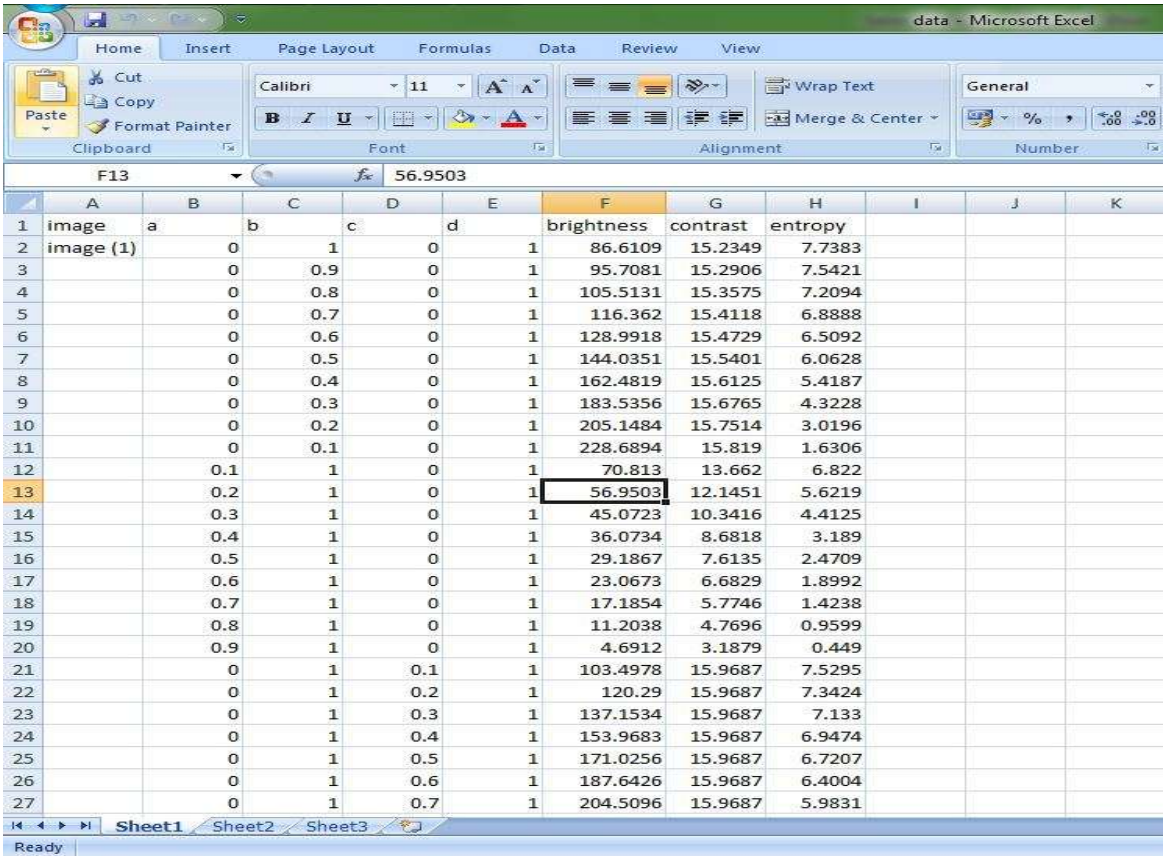


Figure 6.4: MATLAB Implementation



data - Microsoft Excel

Home | Insert | Page Layout | Formulas | Data | Review | View

Cut | Copy | Format Painter | Paste | Clipboard

Calibri | 11 | Font

Wrap Text | Merge & Center | Alignment

General | Number

F13 | 56.9503

	A	B	C	D	E	F	G	H	I	J	K
1	image	a	b	c	d	brightness	contrast	entropy			
2	image (1)	0	1	0	1	86.6109	15.2349	7.7383			
3		0	0.9	0	1	95.7081	15.2906	7.5421			
4		0	0.8	0	1	105.5131	15.3575	7.2094			
5		0	0.7	0	1	116.362	15.4118	6.8888			
6		0	0.6	0	1	128.9918	15.4729	6.5092			
7		0	0.5	0	1	144.0351	15.5401	6.0628			
8		0	0.4	0	1	162.4819	15.6125	5.4187			
9		0	0.3	0	1	183.5356	15.6765	4.3228			
10		0	0.2	0	1	205.1484	15.7514	3.0196			
11		0	0.1	0	1	228.6894	15.819	1.6306			
12		0.1	1	0	1	70.813	13.662	6.822			
13		0.2	1	0	1	56.9503	12.1451	5.6219			
14		0.3	1	0	1	45.0723	10.3416	4.4125			
15		0.4	1	0	1	36.0734	8.6818	3.189			
16		0.5	1	0	1	29.1867	7.6135	2.4709			
17		0.6	1	0	1	23.0673	6.6829	1.8992			
18		0.7	1	0	1	17.1854	5.7746	1.4238			
19		0.8	1	0	1	11.2038	4.7696	0.9599			
20		0.9	1	0	1	4.6912	3.1879	0.449			
21		0	1	0.1	1	103.4978	15.9687	7.5295			
22		0	1	0.2	1	120.29	15.9687	7.3424			
23		0	1	0.3	1	137.1534	15.9687	7.133			
24		0	1	0.4	1	153.9683	15.9687	6.9474			
25		0	1	0.5	1	171.0256	15.9687	6.7207			
26		0	1	0.6	1	187.6426	15.9687	6.4004			
27		0	1	0.7	1	204.5096	15.9687	5.9831			

Sheet1 | Sheet2 | Sheet3

Ready

Figure 6.5: Excel Data File

Chapter 7
RESULT AND ANALYSIS

For analysis section, two prime objectives are considered.

Objective 1: To check whether the data generated from the images are normal or not

Objective 2: To find out the effect of brightness and contrast of an image on the entropy.

7.1 **Analysis of Objective 1**

To perform the objective 1, SPSS is applied on data with 1 sample Kolmogorov-Smirnov Test to check its normality. Following are the hypothesis generated:

$$H_0: The\ data\ is\ not\ normal$$

$$H_1: The\ data\ is\ normal$$

The result of the required test is given below table.

Table 7.1: One-Sample Kolmogorov-Smirnov Test

		Brightness	Contrast	Entropy
N		400	399	400
Normal Parameters[a,b]	Mean	108.535050	13.236645	4.811115
	Std. Deviation	79.0699020	4.5279622	2.4580836
Most Extreme Differences	Absolute	.093	.277	.134
	Positive	.093	.271	.112
	Negative	-.085	-.277	-.134
Test Statistic		.093	.277	.134
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

From the result above, it is statistically proved that the generated data of brightness, contrast and entropy follows a normal distribution. All of these parameters have the significance value of 0 which is < 0.05. Therefore the null hypothesis are rejected and alternative hypothesis are accepted i.e. testing data is normal.

7.2 Analysis of Objective 2

As we are not confident about the data distribution pattern of our testing data, we can move forward to analyses the effect of the parameters. For the purpose, we have created our hypothesis in the following way.

$$H_0: Brightness\ and\ contrast\ have\ no\ significant\ effect\ on\ entropy$$

$$H_1: Brightness\ and\ contrast\ have\ significant\ effect\ on\ entropy$$

To test this hypothesis, linear regression in SPSS is used. The results are analyzed below.

Table 7.2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.830[a]	.689	.688	1.3734948

a. Predictors: (Constant), Contrast, Brightness

From the above table of Model summary, its clear that the R-square value is .689 which suggests that the overall regression model of our purpose can predict 68.9% significantly about the effect of brightness and contrast on entropy. The significance of the model can also be statistically proved with some hypothesis and ANOVA test.

$$H_0: The\ regression\ model\ is\ not\ significant$$

$$H_1: The\ regression\ model\ is\ significant$$

Table 7.3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1657.436	2	828.718	439.291	.000[b]
	Residual	747.049	396	1.886		
	Total	2404.485	398			

a. Dependent Variable: Entropy

b. Predictors: (Constant), Contrast, Brightness

From the ANOVA table, the significance value we got is 0 which is < 0.05. Therefore we have rejected the null hypothesis and accepted the alternate hypothesis. This means that the regression model is significant.

Table 7.4: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.085	.220		-4.929	.000
	Brightness	-.020	.001	-.632	-16.589	.000
	Contrast	.606	.021	1.116	29.307	.000

a. Dependent Variable: Entropy

The above table of coefficients helps to define the regression line which in turn helps to statistically prove the effect of the said parameters. Each of the significance value of constant, brightness and contrast has the significance value of 0 which is < 0.05. Therefore, we can say that the parameters brightness and contrast is individually significant for the regression model. The regression line of the model is defined as below.

$$Entropy = -1.085 - (.020 * Brightness) + (.606 * Contrast)$$

The above regression line can be expressed as, the single unit change in brightness will reduce 0.020 unit of entropy and similarly, one unit change in contrast will increase 0.606 unit of entropy.

Chapter 8
SUMMARY AND CONCLUSION

Advancements in the field of image processing research domain will enhance the storage, presentation and retrieval of visual data much fruitful. As a part image retrieval and its analysis have its significance in identifying and measuring different factors in different images. In this research work, we have proposed the methodology to measure the semantic gap factors in different image based CAPTCHAs to define relation between usability issues and semantic gap. Different techniques have been literature reviewed and we found a number of methods for measuring the semantic gap. As target images, we have considered different image based CAPTCHAs to deal with. We shall also provide a designing factor requirement for the CAPTCHA designers as the prime objective of CAPTCHA includes robustness along with usability.

As per the objectives defined for this research work, the next step is to calculate entropy, contrast and brightness of image based CAPTCHAs to analyze the effectiveness of the methods described in the literature review. After that we shall be able to define the correlation between the semantic gap and usability factors in image based CAPTCHAs.

From results it can be concluded that if all the other factors are constant, the increasing value of contrast will increase amount of entropy and as a result, semantic gap will be less.

If all the other factors are constant, the increasing value of brightness will decrease the amount of entropy and as a result, semantic gap will be high.

Noise also plays a vital role in semantic gap. For future work calculation of noise in the image will help to decrease down the semantic gap.

Chapter 9
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Chapter 10
APPENDIX

Table 9.1 Abbreviations

ACO	Ant Colony Optimization
ANN	Artificial Neural Network
BOVW	Bag of Visual Words
CAPTCHA	Completely Automated Public Turing Test to Tell Computers and Humans Apart
CBIR	Content Based Image Retrieval
CCV	Color Coherence Vector
COM	Co-occurrence Matrix
HSV	Hue Saturation Value
IGA	Interactive Genetic Algorithm
KNN	K-Nearest Neighbor
LDA	Latent Dirichlet Allocation
MATLAB	Matrix Laboratory
MSRM	Maximal Similarity Based Region Merging
OOP	Object Oriented Programming
RGB	Red Green Blue
SSML	Sparse Semantic Metric Learning
TBIR	Text Based Image Retrieval