Stage II report
on

LABELLING HIDDEN SERVICES WITH IMAGE RECOGNITION

Submitted
in partial fulfillment of
the requirement of the degree of

M.Tech in Software Engineering

by

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Under the Guidance of
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STATEMENT OF CANDIDATE

I state that work embodied in this Project entitled **"Labelling Hidden Services with Image Recognition"** form my own contribution of work under the guidance of **Dr. S. G. Bhirud** at the Department of Computer Engineering, Veermata Jijabai Technological Institute, Mumbai. The report reflects the work done during the period of candidature but may include related preliminary material provided that it has not contributed to an award of previous degree. No part of this work has been used by us for the requirement of another degree except where explicitly stated in the body of the text and the attached statement.

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CERTIFICATE

This is to certify that Akansha Sudhirkumar Singh, a student of M.Tech in Software Engineering, has completed the Stage II report entitled, **"*Labelling Hidden Services with Image Recognition*"** to our satisfaction.

Dr. S. G. Bhirud
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Place: VJTI, Mumbai
Date: /05/2022

APPROVAL SHEET

The report **"*Labelling Hidden Services with Image Recognition*"** submitted by Akansha Sudhirkumar Singh[202191015], is found to be satisfactory and is approved for the Degree of M.Tech in Software Engineering.

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Akansha Sudhirkumar Singh

ABSTRACT

Dark Web can be taken advantage of by the cyber criminals or terrorists to fulfil their illicit motives. Various studies points out to how dark web is used for illegal activities. The web service that uses TOR technology to stay secure is termed as Tor hidden service. Hidden services contains multimedia data. Visual data forms a large portion of Dark Web which cannot be ignored. However in case of existing researches on dark web visual contents, most of them are focused on a specific category of contents like Child Sex Abuse(CSA) materials, even if they consider multiple classes only some specific classes are addressed, dataset is not available publicly, and image analysis is not confirmed with textual analysis. The proposed work makes use of a dataset which consists of a number of hidden services containing both text and visual data. The image data present in this dataset will be labelled into unique classes or categories that can be formed using available dataset. This labelled dataset will be made publicly available. The model will be trained using train data and validated using validation data. Model will be subjected to identify the category of any test image. The proposed work not only includes classifying dataset into classes belonging to other categories of contents that existing works do not cover but also confirming correlation between text and image data by performing analysis of images and related text data. This will help in identifying the type of hidden service effectively.

Keywords: Dark Web, Image Analysis, Hidden Service, Image Categorization

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Abbreviations

TOR	The Onion Router
CSA	Child Sex Abuse
TOIC	TOR Image Categories
CREIC	Compass Radius Estimation for Image Classification
SIFT	Scale-invariant feature transform
YOLO	You Only Look Once
BOW	Bag of Words
BOVW	Bag of Visual Words
SAKF	Semantic Attention Keypoint Filtering
DUSI	Darknet Usage Service Images
HSV	Hue Saturation Value
NSFW	Not Safe For Work
SSD	Single Shot Detection
CNN	Convolutional Neural Networks
SAGE	Scientific Advisory Group for Emergencies
IEEE	Institute of Electrical and Electronics Engineers
DUTA	Darknet Usage Text Addresses
TF-IDF	Term Frequency — Inverse Document Frequency
JSON	JavaScript Object Notation
HTML	Hypertext Markup Language
CSS	Cascading Style Sheets

Chapter 1

INTRODUCTION

1.1 Overview

1.1.1 What are Hidden Services?

A hidden service is a site you visit or a service you use that uses Tor technology to stay secure and, if the owner wishes, anonymous. “Hidden services” are also known as “onion services”.[2]

1.1.2 Why and Who uses it?

A hidden service is identified by its onion url. Tor is able to interpret such urls and forward data packets to and from a hidden service, guaranteeing anonymity in both directions. Though many users use this anonymity for privacy, the anonymity provided by TOR represents a perfect breeding ground for illegal activities. Tor hidden services have been accused of providing protection to terrorists and are known to host marketplaces for drugs, weapons, and pedo-pornography.

1.1.3 What is TOR?

One of the famous networks into the Dark Web is The Onion Router (TOR), and its content can be consulted through the TOR Browser or through the Surface Web thanks to projects like TOR2WEB.[1]

1.1.4 What is Image Tagging?

Image tagging is the process of labelling images with keywords as per Ryne[5].

1.1.5 Image Tagging in Dark Web

Identifying the object present in dark web images for any hidden service is crucial. This can help in understanding the kind of hidden service one is dealing with.

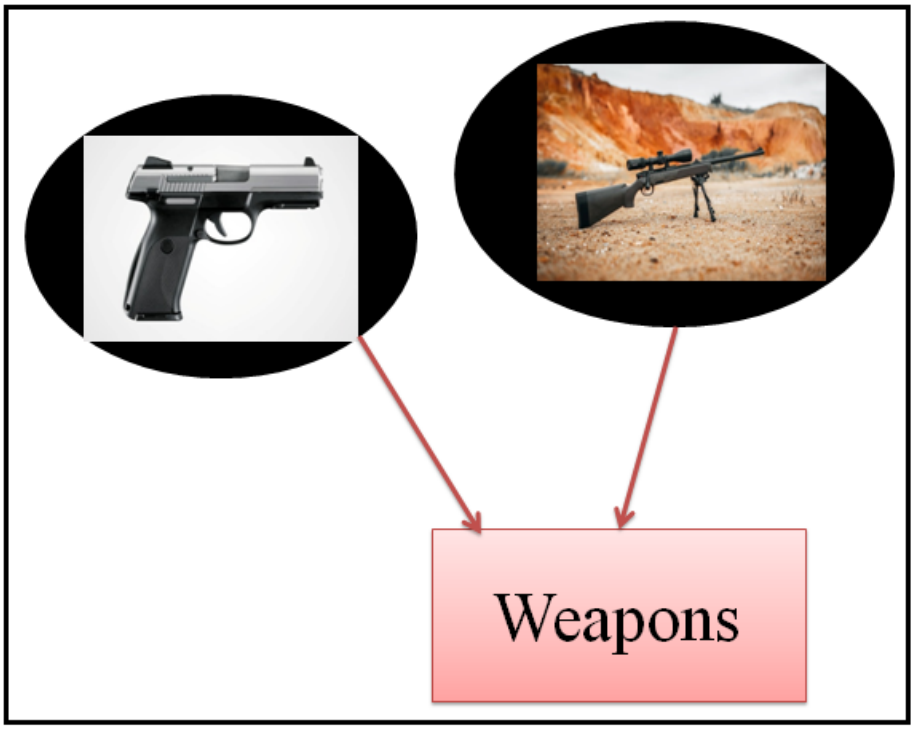

Figure 1.1: Identification of Objects in Images as Weapons

For example in Figure 1.1 shows how identifying the object in images as weapons helps one understand that this hidden service is dealing with weapons.

1.2 Motivation

Hidden services can be used to carry out illegal and unethical activities by cyber criminals or terrorists. As per Susan[13] approximately 75% of dark marketplace listings include image data, indicating the importance of considering image content for investigative analysis. However, visiting thousands of hidden services to look for visual information containing illegal acts manually requires a considerable amount of time and resources. A system which can automatically label images in various hidden services is highly desirable. There are studies and projects that includes analysis of image data. Most of the existing researches about image labeling on Dark Web focuses on a specific domain such as identifying Vendors or Child Sex Abuse Material. Even if some researches considers content having more than one class, for example weapons, drugs, counterfeit money, etc., focus is on some specific classes leaving other classes out of consideration. Thus the motivation of this project is to contribute to the field of dark web image analysis and confirm the result of analysis with textual analysis of hidden services using the available dataset.

1.3 Problem Statement

"Labelling Hidden Services with Image Recognition" implies to identify type of hidden services by recognising the category of its images. The aim is to categorize the images present in the dataset. The goal is also to create, present and make publicly available a labelled dark web image dataset, and confirm correlation between textual data and image data by performing analysis of image and related text data.

1.4 Project Scope

- Making publicly available a labelled dataset.
- Hidden service identification by image categorisation.
- Text data analysis for confirming co-relation between text data labelling and image categorisation.

1.5 Future Scope

Predicting type of hidden service based on correlation between text and image analysis. Eg: Drugs, Weapons, etc.

Chapter 2

LITERATURE REVIEW

2.1 Literature Survey

Fidalgo et al[1] presents TOIC (TOR Image Categories) dataset with five different illegal classes. These images in dataset is classified using Bag of Visual Words model with fusion of dense SIFT and Edge-SIFT features that can create an efficient model to detect and categorise illegal content. Edge-SIFT descriptors with fixed radius was proposed by Xie et al[18]. Fidalgo et al[20] introduced concept of Ideal Radius Selection which performs better. Fidalgo et al introduced method of Compass Radius Estimation for Image Classification (CREIC) which estimates the optimum radius value of the Compass Operator for a given dataset to extract the most relevant descriptors from the edge images.Using fusion of these features and SIFT descriptors, Fidalgo et al. obtained higher accuracy rates than Edge-SIFT descriptors. First Fidalgo[1] tested CREIC method on a well-known dataset for classification, Butterflies [13] and then on TOIC. The method yields an accuracy of 86.62% in Butterflies and 92.49% in TOIC.

Figure 2.1: Classes in TOIC Dataset

Vaibhav Pandit.,[9] presents an approach to caption black and white images using transfer learning by implementing Inception v3, a model which is developed by Google. The dataset consists of 8000 photos with upto five captions for each photo. This method yields an accuracy of 45.77% on the validation set.

Dr. S. V. Viraktamath.,[10] provides insights on some related works of paper-currency recognition and has explained the benefits and disadvantages of various currency recognition systems. Most of the algorithms analysed used images of original currencies taken from camera to create datasets and compared these values with the test images to differentiate between original and counterfeit.

Risab Biswas.,[11] illustrates the importance of drug identification and drug discovery in world healthcare sector and how this solution shows accurate results in identifying the drugs correctly, given the molecular structures.

Tufail Sajjad Shah Hashmi.,[12] presents a comparative analysis between YOLOV3 and YOLOV4 for weapons detection. A total of around 9000 images containing gun and pistol was used for this research. The dataset was divided into train and test data and evaluated using both YOLOV3 and YOLOV4 models. YOLOV4 outperforms YOLOV3 in this comparison.

Enrique Alegre.,[7] introduces Semantic Attention Keypoint Filtering, which combines saliency maps with Bag of Visual Words (BOVW). This strategy filters non-significant features from the object of interests at the pixel level. This paper addresses the problem of separating foreground objects with background objects to remove unnecessary details from the subjected images. Eduardo Fidalgo[8] evaluated SAKF on a custom Tor image dataset against CNN features: MobileNet v1 and Resnet50, and BoVW using dense SIFT descriptors, achieving a result of 87.98% accuracy that is outperforming all other approaches.

Joao Marques[22] thousands of onion addresses can be collected using memory extraction from servers belonging to the Distributed Hash Table using cheap resources in a small amount of time. This research can be used as a stepping stone to extract intelligence that can be used to to secure legitimate content and monitor or block illegitimate content as anonymity is not only used for providing privacy to legitimate users but also a shield to dark vendors dealing with illegitimate content on the dark web.

Xiangwen Wang.,[21] presents an approach to link multiple accounts of the same darknet vendors through photo analytics. Xiangwen analysed 3 large markets Agora, Evolution, and SilkRoad2, which are now closed, using deep neural networks. However, in this research neither image metadata nor text-based data was considered for classification, which might have improved the model's accuracy.

Rubel Biswas.,[16] presents a custom dataset named DUSI (Darknet Usage

Service Images) evaluation using both Perceptual Hashing and Bag of Visual Words (BoVW). The dataset is divided into services and not services images.

	Main Class	Sub-classes	Test Samples	Templates
Services	Cryptocurrency		294	15
	Cryptolockers	Type-01	2	1
		Type-02	1	1
		Type-03	31	1
		Type-04	154	1
		Type-05	38	1
		Type-06	10	1
		Type-07	2	1
		Type-08	1	1
		Type-09	3	1
		Type-10	1	1
	Hosting	Directory	18	2
		File-Sharing	23	1
		Search-Engine	3	1
		Server	2	2
	Locked		79	14
	Social-Network	Chat	5	1
		Email	23	1
Not Services			644	0
Total:			1334	47

Figure 2.2: The main features of DUSI dataset[16]

In perceptual Hashing, hash code of each image of the services image is calculated and stored. New image is subjected to hashing and then the hash code is compared with the hash code that is stored. If the Hamming Distance between both the hash code is less than the threshold value(10) then the new image is a service image otherwise it is not. Perceptual Hashing do not require training of the model thus the time investment is less than BOVW. Also Perceptual Hashing provided higher accuracy than BOVW for the given dataset.

Susan Jeziorowski.,[13] examines image metadata and explore several image hashing techniques. Their study reveals that approximately 75% of dark mar-

ketplace listings include image data, indicating the importance of considering image content for investigative analysis. Also it was found that 2% of image data considered had metadata associated with them and 50% of images hashes were observed to be repeated among marketplace listings which tells about the frequency of image reuse among dark vendors. Thus this research reveals the effectiveness of image hash analysis for identifying similar images between dark marketplaces.

Saiba Nazah.,[3] provides Dark Web threat analysis and detection using a systematic approach following steps as define research questions, develop search strategy, screening and selecting study, data extraction, synthesize and analyze data, report review. Around 65 papers were analysed from various sources. The list of the crime threats were identified from the papers. Many crime detection studies have been done to locate the crimes or criminals in the dark web. The detection techniques and law enforcement methods applied and initiated for this purpose were discussed.

Abhishek Gangwar.,[24] presents a critical review of automatic pornography and Child Sex Abuse (CSA) detection techniques in images and videos. Two publicly available pornographic databases and a real world CSA dataset provided by Spanish Police Forces. Five methods evaluated were Skin Detection by color, Nudity Detection by skin color, HSVColor-SIFT, ShallowCNN, Open NSFW. This research observed that the methods consisting of multiple features performed better than those using simple features like skin color or single image descriptor. Deep learning based methods were observed to outperform all other methods.

Shrey Srivastava.,[25] compares 3 major image processing algorithms: Single Shot Detection (SSD), Faster Region based Convolutional Neural Networks (Faster R-CNN), and You Only Look Once (YOLO) to find the fastest and most efficient of three. Out of the three Object Detection Convolutional Neural Networks that were analysed, Yolo-v3 shows the best overall performance. This comparison is done on the open-source COCO dataset by Microsoft, to ensure a homogeneous baseline. However the choice of algorithms and the result is largely dependent on the use case.

Pankaj Kumar.,[26] introduces a deep learning convolutional neural network (CNN) model to identify Anthracnose disease of mango, which is one of the common diseases in mango plants and can be detected from mango leaves. The images of leaves are captured from the Mango farms in small village in Kolhapur city Maharashtra state and Khanapur taluka in Karnataka state, India. The dataset has been classified in four classes named as Mango Anthracnose, Mango healthy, other diseased and other healthy. The dataset is split into train and validation sets. Model is trained on train dataset and validated using validation dataset. Any real time image of leaf can be subjected to classification through this model.

Wisam A. Qader.,[17] presents overview of Bag of Visual Words (BOW), its importance, its working, applications and challenges. In bag of words (BOW), the number of each word is counted that appears in a document, the frequency of each word is used to know the keywords of the document, and a frequency histogram is made from it.

Shubhdeep Kaur and Sukhchandan Randhawa[29] and Abhineet Gupta[15] explains how dark web is misused and provides an overview of dark web, ways to access dark web, types of criminal activities on dark web, types of attacks using dark web, impact of dark web on cyber security and role played by law enforcement agencies in dealing with it. Thus providing reader with insights on the dark side of dark web so that the reader can take preventive measures while accessing dark web.

Arber S. Beshiri.,[28] discussed and provided results on the indirect number of users in Kosovo and in the world in 2018. Thus providing insights about the influence of dark web in different spheres of society. Not only dark web has influence on the world but global events also have impact on dark web. Influence of pandemic is discussed by Abdul Razaque.,[23] showing how dark websites related to PPE has impact of COVID-19. It was also observed that the provider, vendor and user of dark web had increased post COVID-19 and thus there is increase in criminal activities whether it is sale of illegal goods or accessing illicit materials.

Akshaya Udgave.,[34] provides the analysis on the use of text mining techniques to help readers keep track of recent developments in the field of design science. Text mining techniques discussed are Information Extraction, Information Retrieval, Categorization, Clustering, Summarization.

Said A. Salloum.,[32] collected and analyzed three hundred different articles from Springer, Wiley, Science Direct, SAGE, IEEE, and Cambridge using text mining techniques. Main tasks for the analysis of text in this study were text clustering (k-means), association rule, word cloud, and word frequency. The articles were analyzed for topic of mobile education for medical domain.

Albert Weichselbraun.,[30] introduces Inscriptis which provides a library that can help converting HTML page contents to plain text. Albert also points out how Inscriptis excels when it comes to interpreting complex HTML constructs such as nested tables when alternatives fail to interpret them. Inscriptis also supports annotation rules which can be used for analysing the HTML structure.

David Mathew Thomas.,[27] used a methodology to gather data from required service and analyse it for the requirements of customer. Social network site Reddit was crawled using the web crawler scrapy and the data was analysed to find out the number of times topics were searched.

Mhd Wesam Al Nabki.,[14] created Darknet Usage Text Addresses (DUTA) dataset that is extracted from the Tor hidden service Darknet. Dataset is divided into twenty-six classes for this research. Wesam has categorized illegal activities of Tor hidden service by using two text representation methods, Term Frequency Inverse Document Frequency and Bag of Words combined with three classifiers, Support Vector Machine, Logistic Regression, and Naive Bayes with high accuracy. The combination of TF-IDF text representation with the Logistic Regression classifier achieved highest accuracy.

Oleksandr Matveiev.,[31] investigated two text categorization approaches K-Nearest Neighbour and the Support Vector Machine algorithms on a JSON dataset containing 40000 entries. The performance of both the algorithms were evaluated on how accurate and how quickly they classified that shoes category based on the brand. The results can further be improved by adding more testing data.

Bassel Alkhatib.,[33] introduced a three step approach to put a dark website under investigation. The approach consisted of three parts. The first part consisted of The Dark Crawler Darky which scans whole website and extracts data from it. The second part included The Cleaner which performs prepossessing on the extracted data. The third part included The Dark Miner which applied Association Rules and Clustering to illustrate all the gained results. The design of crawler and the usage of data mining techniques may differ from one website to another.

Zheng Yan.[35], proposes a feature attention network. The model typically has three parts that is backbone, correlation learning network and feature refinement network. As backbone Resnet-101 or VGG is used. This backbone is followed by feature refinement network. Feature refinement network consists of sets of feature transform blocks and feature refinement blocks. Feature transform block consists of layers used for transformations to get information representations. Feature vectors obtained are subjected to layers of feature refinement blocks. The output is further passed to correlation learning network consisting of convolution, pooling layers to predict final output that is classes for any image. This model gives good classification accuracy when on tested on open source datasets MSCOCO2014 and VOC2007.

Lingyun Song.[36], proposes a Multi-Modal CNN for Multi-Instance Multi-Label image classification, called MMCNNMIML. Instead of denoting one image with a single class while training, each image is associated with a set of text descriptions. These images and associated text descriptions both are passed as input to the model. Models consists of four modules, one each belonging to visual instance generation and group context generation, followed by multi-modal instance generation and classification module. Open source datasets MIRFLICKR-25K and ImageCLEF are subjected to this model and the per-

formance is compared with other CNN models such as KISAR, Vgg16, Resnet, Xception, SSDH, where it outperforms.

Jubin[37], discusses image identification, challenges in image-based identification and deep neural network implementation for flower identification using tensorflow. A total of 2171 images in three categories that is daisy, dandelion and roses are part of the dataset. Dataset is an ImageNet dataset. This dataset is trained using deep neural network using tensorflow with MobileNet. The prediction accuracy obtained is more than 90%.

Manali Shaha.[38], proposes to make use of transfer learning by fine-tuning pre-trained networks. These networks include AlexNet, VGG16 and VGG19 (VGG is Visual Geometry Group). These models are tested on open source datasets GHIM10K and CalTech256. The performance of all three CNN are compared for both the datasets using the metrics such as recall, precision and F-score. Recall specifies the number of sample correctly classified as positive to the total number of positive samples. Precision specifies the number of sample correctly classified as positive to the total number of samples classified as positive, whether they are positive or not. F-score is harmonic mean of precision and recall and points to model's accuracy. All the three CNNs performed better for dataset GHIM10K. VGG19 CNN architecture performed best on both these datasets.

Sajja Tulasi Krishna.[39], provides a survey on various deep learning architectures. These architectures includes LeNet, AlexNet, GoogleNet, VGG16, VGG19, Resnet50 etc. Transfer learning using these pretrained models is also covered in this survey. These architectures are typically tested on are open source datasets. In this paper Sajja discusses various CNN layers, pre-trained models by transfer learning, datasets used and accuracy of model on datasets. The results observed in this survey pointed that accuracy of the model is influenced by size of data for each category, categories and also the number of epochs.

Mahbub Hussain.[40], conducts a study on transfer learning using pre-trained Inception-v3 model to retrain on two different datasets and results are compared. However testing is not done on custom darkweb dataset rather on public datasets.

Shahzad Qaiser.[41], discusses TF-IDF in the research including its technique, working, strengths, and limitations. Saiba Nazah.[42], proposes analysis of Dark web forum data, using combination of techniques such as BOW, TF-IDF and K-means

2.2 Comparative Research Table

Sr No.	Research	Strengths	Limitations
1	Illegal Activity Categorisation in DarkNet Based on Image Classification Using CREIC Method	Efficient classification of five categories of dark web images	Some specific category of images was addressed. Proprietary software Matlab is used.
2	Evolution of Dark Web Threat Analysis and Detection: A Systematic Approach	Systematic Literature Review (SLR) is provided to identify threats in Dark Web for the researchers and specialists in the Cyber security field.	Methods to analyse image contents of Dark Web to identify the hidden service is not covered.
3	Classifying suspicious content in TOR darknet through Semantic Attention Keypoint Filtering	An efficient method that focuses only on the object of interest is proposed.	The images extracted from TOR do not always show object of interest in ideal situation for the method proposed.
4	Classifying Suspicious Content in Tor Darknet	SAKF is being evaluated on a custom dataset against CNN features: MobileNet v1 and Resnet50, and BoVW using dense SIFT descriptors. It is outperforming other methods.	SAKF can be compared with some additional methods apart from the ones mentioned to check its performance.
5	DeepCap: A Deep Learning Model to Caption Black and White Images	In this paper researcher focuses on a method of captioning of black and white images using transfer learning unlike the existing models which are for coloured images.	Accuracy obtained by the model is around 45%. Accuracy of the model is required to be increased probably by training the model on a bigger dataset.

6	Review on Detection of Fake Currency using Image processing Techniques	The research concluded that K-means algorithm and SVM algorithm provides 97% accuracy in detection of fake currency.	The currency image is taken from only one side or either front or back, which can be further improved by taking the images from different angles.
7	Drug Discovery and Drug Identification using AI	The method introduced can reduce the entire drug discovery process of clinical trials to a very small time of 3-4 months (which generally takes 10-12 years).	Research is focused on drug identification using molecular structure. This will not be helpful in detection of drugs through images.
8	Application of Deep Learning for Weapons Detection in Surveillance Videos	Comparative analysis of YOLOV3 and YOLOV4 for weapons detection. YOLOV4 outperforms YOLOV3.	Weapons used in dataset is only gun and pistol.
9	Towards Image-Based Dark Vendor Profiling	This paper focuses on the effectiveness of using image hashing to identify similar images between dark marketplaces for vendor identification.	This research leaves behind a large set of data which are not related to vendors on the dark web.
10	Classifying Illegal Activities on Tor Network Based on Web Textual Contents	The combination of TFIDF with the Logistic Regression classifier achieved highest accuracy for text dataset Darknet Usage Text Addresses (DUTA) created from hidden services and labelled for research.	Graphical data analysis is not considered leaving out the large portion of hidden services data.

11	The Dark Web as a Phenomenon: A Review and Research Agenda	A literature review was conducted into the roles the dark web plays in modern digital society, its enablement of cybercrime and its relationship with law enforcement.	Methods to analyze dark web data are not covered in the research.
12	Recognition of Service Domains on TOR Dark Net using Perceptual Hashing and Image Classification Techniques	The research demonstrates that perceptual hashing performs better than Bag of Visual Words on DUSI Image dataset.	There was no mention of text data correlation with images. Dataset used is not available publicly.
13	An Overview of Bag of Words;Importance, Implementation, Applications, and Challenges	This study is useful in terms of introducing the BoW method to the new researchers and providing a good background with associated related works.	BOW may face some challenges in which the image will be difficult to be detected or fully unrecognized such as viewpoint variation, illumination, deformation.
14	Spatial Pooling of Heterogeneous Features for Image Classification	A novel framework fusing complementary descriptors for image classification is introduced to provide high accuracy.	Model works well for some datasets but not suitable for others.
15	Semi-local Affine Parts for Object Recognition	The model is focused on identifying image features having a characteristic appearance and elliptical shape and performs well for butterflies' dataset.	Model may not perform well for other type of datasets.

16	Compass radius estimation for improved image classification using Edge-SIFT	The research suggested how different radii of compass operator of original image can have impact of classification accuracy using BOVW	The better radius selection method such as saliency map can be explored.
17	You Are Your Photographs: Detecting Multiple Identities of Vendors in the Darknet Marketplaces	The research demonstrated how photo analytics can be used to identify multiple accounts of same vendor.	This research leaves behind a large set of data which are not related to vendor accounts on the dark web.
18	Tor: Hidden Service Intelligence Extraction	The research shows that it is possible to gather thousands of onion addresses through memory extraction of servers belonging to the Distributed Hash Table in a small amount of time.	The research shows the necessity for improvement in this area to protect the anonymity of the users.
19	Influence of COVID-19 Epidemic on Dark Web Contents	The research identified how the Dark Web has been influenced by recent global events, such as the COVID-19 epidemic.	The investigation experienced drawbacks, such as covering a relatively small portion of the Dark Net.
20	Pornography and Child Sexual Abuse Detection in Image and Video: A Comparative Evaluation	This research observed that the methods consisting of multiple features performed better for automatic pornography and Child Sex Abuse (CSA) detection. Deep learning based methods were observed to outperform all other methods.	Since there is no storage of pornography and Child Sex Abuse (CSA) contents for research. Larger datasets can be used for testing for better and accurate results.

21	Comparative analysis of deep learning image detection algorithms	The research concludes Yolo-v3 shows the best overall performance against SSD, Faster R-CNN for open-source COCO dataset.	This comparison is done on the open-source COCO dataset, to ensure a homogeneous baseline but the choice of algorithms is largely dependent on the use case.
22	Classification of Mango Leaves Infected by Fungal Disease Anthracnose Using Deep Learning	The research will help farmers save their plants by early detection of Anthracnose disease of mango.	The method was focused on a particular disease of the plant. The efficiency of this model on other kinds of diseases is not explored.
23	Data Analysis by Web Scraping using Python	The research shows crawling of a social network site Reddit and the number of times terms were searched on it thus this research can be helpful if the goal is to analyse a site.	The research misses out on analysis of other data apart from the searched terms on site.
24	Dark Web and Its Impact in Online Anonymity and Privacy: A Critical Analysis and Review	The research gives the number of anonymous users in Kosovo and worldwide and provides results about the influence of the Dark Web in different spheres of society.	The accuracy of the counts provided in this paper cannot be verified as anonymity is not verifiable.
25	Dark Web: A Web of Crimes	This research makes aware the reader criminal activities and incidents which take place over the Dark Web and take preventive measures.	The research does not include hidden services analysis.

26	Inscriptis - A Python-based HTML to text conversion library optimized for knowledge extraction from the Web	Inscriptis excels when it comes to interpreting complex HTML constructs such as nested tables when alternatives fail to interpret them and supports annotation rules.	Incriptis working on multiple pages was not discussed in this research.
27	Towards Classifying HTML-embedded Product Data Based On Machine Learning Approach	The research evaluated two popular algorithms for text classification that are KNN and SVM on a JSON dataset providing knowledge about text analysis techniques.	The research gave satisfactory results but not the best. Increasing the testing data can help get better results.
28	Using Text Mining Techniques for Extracting Information from Research Articles	The research provided insights on various text mining techniques and these techniques are used to analyse 300 articles from six databases for the topic of mobile education for the medical domain.	The research was focused on a particular topic rather than exploring more topics which can lead to more interesting patterns.
29	Mining the Dark Web: A Novel Approach for Placing a Dark Website under Investigation	The research introduced an efficient three step method to investigate any website consisting of crawling, cleaning and mining.	The design of crawler and the usage of data mining techniques may differ from one website to another.
30	Text Mining and Text Analytics of Research articles	The research discusses text mining techniques such as Information Extraction (IE), Information Retrieval (IR), Categorization, Clustering, and Summarization.	The text mining techniques are not discussed in detail and are limited.

31	Multi-Label Image Classification by Feature Attention Network	A feature attention network is proposed which improves the accuracy of predictions.	Not tested on custom dark web datasets. Tested only on public datasets.
32	A Deep Multi-Modal CNN for Multi-Instance Multi-Label Image Classification	Instead of denoting one image with a single class while training, each image is associated with a set of text descriptions.	Not tested on custom dark web datasets. Tested only on public datasets.
33	A Case Study of Image Classification Based on Deep Learning Using Tensorflow	The research discusses image identification, challenges in image-based identification and deep neural network implementation for flower identification using tensorflow.	Multiple label assignment is not done with images. Not tested on darkweb dataset.
34	Transfer learning for image classification	The research proposes to make use of transfer learning by fine-tuning pre-trained networks. These networks include AlexNet, VGG16 and VGG19.	Networks such as Resnet and Mobilenet are not included.
35	Deep Learning and Transfer Learning Approaches for Image Classification	The research provides a survey on various deep learning architectures. These architectures includes LeNet, AlexNet, GoogleNet, VGG16, VGG19, Resnet50 etc.	Testing is not done on custom darkweb dataset.

36	A Study on CNN Transfer Learning for Image Classification	A study is conducted on transfer learning using pre-trained Inception-v3 model to retrain on two different datasets and results are compared.	Testing is not done on custom darkweb dataset rather on public datasets.
37	Text Mining: Use of TF-IDF to Examine the Relevance of Words to Documents	TF-IDF is discussed in the research including its technique, working, strengths, and limitations.	It is not compared with other techniques.
38	An Unsupervised Model for Identifying and Characterizing Dark Web Forums	Dark web forum data are analyzed using combination of techniques such as BOW, TF-IDF, K-means, etc.	Only text data is analysed and not image data.

2.3 Literature Gap

1. Most of the methods or techniques that considers analysis of Dark Web graphical data are focused on a particular domain like Child Sex Abuse (CSA) or Weapons.

2. A large portion of dark web image data related to other categories is left out.

3. Even if some researches considers having content from more than one class as seen in TOR Image Categories(TOIC) and Darknet Usage Service Images(DUSI), focus is on some specific classes leaving other classes out of consideration.

4. Dataset used in these researches are not public.

5. The analysis of text data related to respective Image data to confirm the correlation is not done. This correlation between text and Image data can help in identifying the type of hidden service accurately.

Chapter 3

PROPOSED APPROACH

3.1 Dataset Overview

Dataset that is to be used for the research consists of set of hidden services. There are different kind of files in Hidden Services. Each hidden service consists of number of HTML, CSS, JavaScript, Image and other files. Each hidden service in the dataset looks as shown in figure 3.1

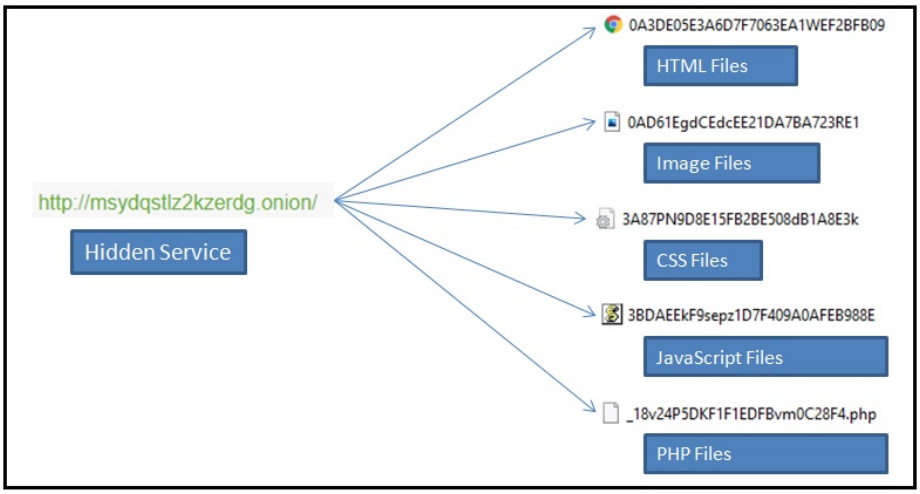

Figure 3.1: A Hidden Service in the Dataset

3.2 Overview of Proposed Approach

The proposed approach is shown in figure 3.2.

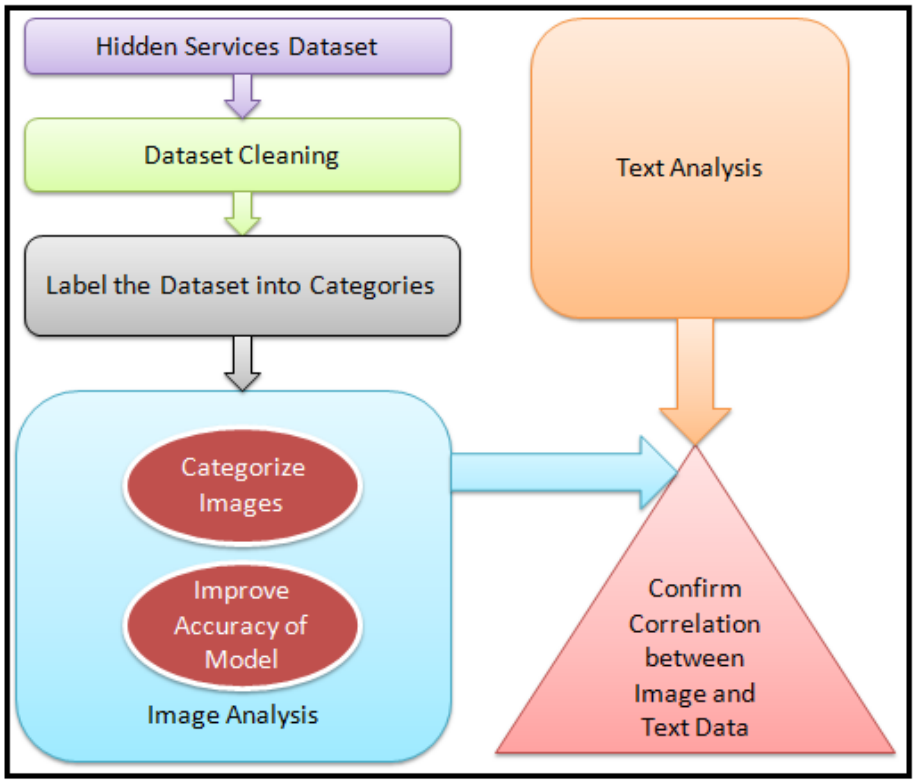

Figure 3.2: An Overview of Proposed Approach

1. The dataset will be analysed and cleaned manually.
2. The classes or categories and may be subcategories will be identified and image data will be labelled accordingly.
3. The dataset will be divided into train and test data.
4. The model will be trained on the train data and validated using test data.
5. This trained model can be used to classify any image from the dataset.
6. The text data associate with image mentioned in step 5 will be analysed.
7. Correlation between the Image data and text data will be confirmed on the basis of results obtained in step 5 and step 6.

3.3 Data Cleaning

Figure 3.3 shows approach of data cleaning

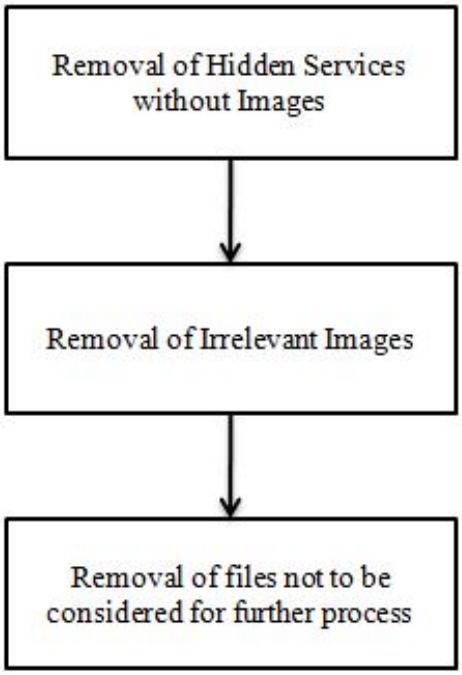

Figure 3.3: Data Cleaning Approach

1. The hidden services without image data will be separated.
2. The images which are irrelevant like blank images will be eliminated.
3. The files which will not be considered for further analysis like cascading style sheets will be eliminated.

3.4 Planned Timeline

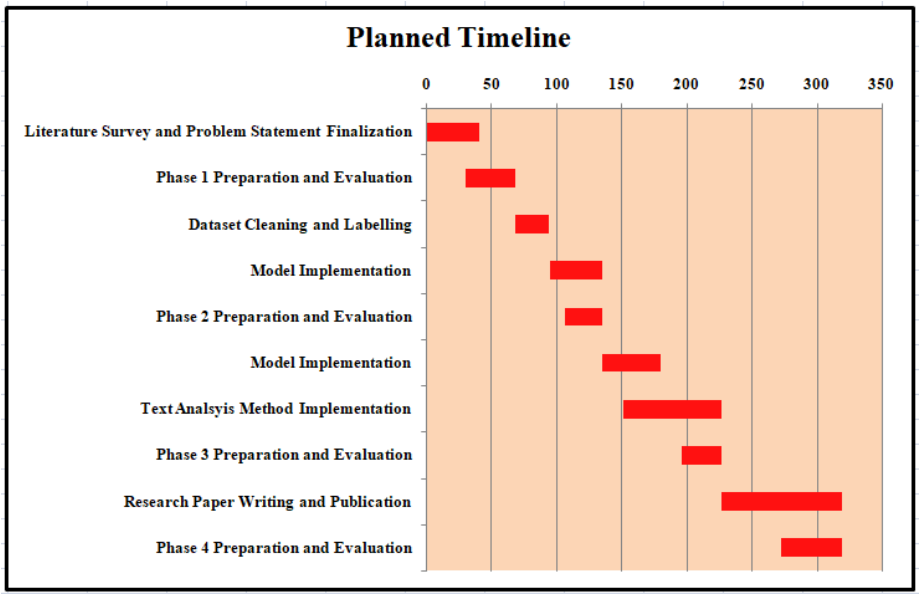

Figure 3.4: Planned Timeline of Work

Chapter 4

IMPLEMENTATION

4.1 Labelling of Image Data-set

1. Number of Images obtained after data cleaning is 1095.
2. The images are labelled into five categories manually.
3. The five classes are as below:
   (a) Card
   (b) Device
   (c) Hacker
   (d) Money

4.2 Train-Test Split of Image Data-set

Data-set is divided into training and validation data in the ratio of 80-20% with 872 training images and 218 validation images respectively.

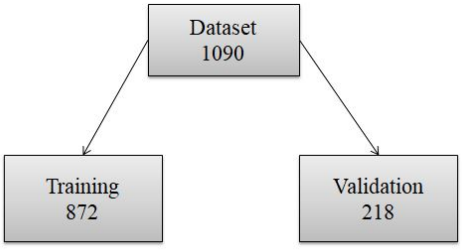

Figure 4.1: Number of Images in Training and Validation

4.3 Model for Image Analysis

Process of implementation of model for identifying the category of image is given below.

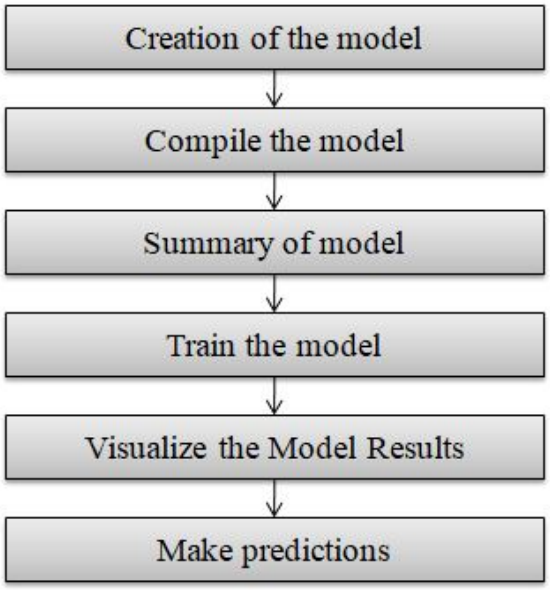

Figure 4.2: Process of Image Analysis

4.4 Architect the Model

1. The model is sequential that starts with re-scale layer.
2. The re-scale layer is followed by four convolution layers with activation function relu each.
3. Each convolution layer is followed by max-pooling layer.
4. Flatten layer is used, followed by dense layers with last dense layer having nodes same as number of classes that is five.
5. For compilation of the model adam optimizer is used.
6. Epochs used is 30.

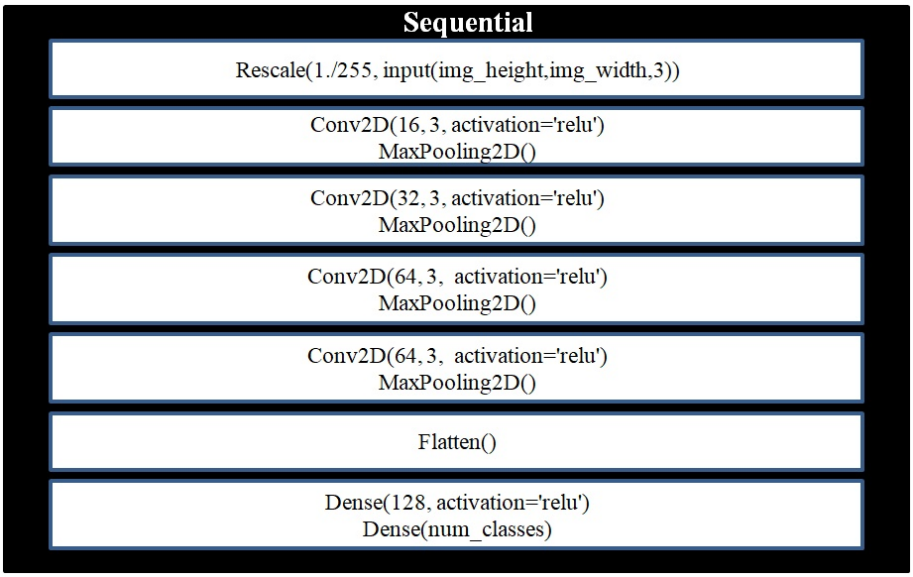

Figure 4.3: Model for Image Analysis

4.5 Visualize Model Results

Training and Validation accuracy and loss for some epochs are given below.

Epoch	Training Loss	Training Accuracy	Validation Loss	Validation Accuracy
1	48.88	90.37	36.80	91.74
6	13.26	95.76	23.31	94.95
11	7.05	97.36	29.67	96.33
16	1.87	99.43	29.67	96.33
21	0.82	99.77	25.12	96.79
26	0.65	99.77	24.92	96.33
30	0.65	99.77	24.10	96.33

Figure 4.4: Epochs Accuracy and Loss

Training and validation accuracy is shown in figure 4.4. Training accuracy upon training on 30 epochs comes to 99.77% and validation accuracy comes to 96.33%.

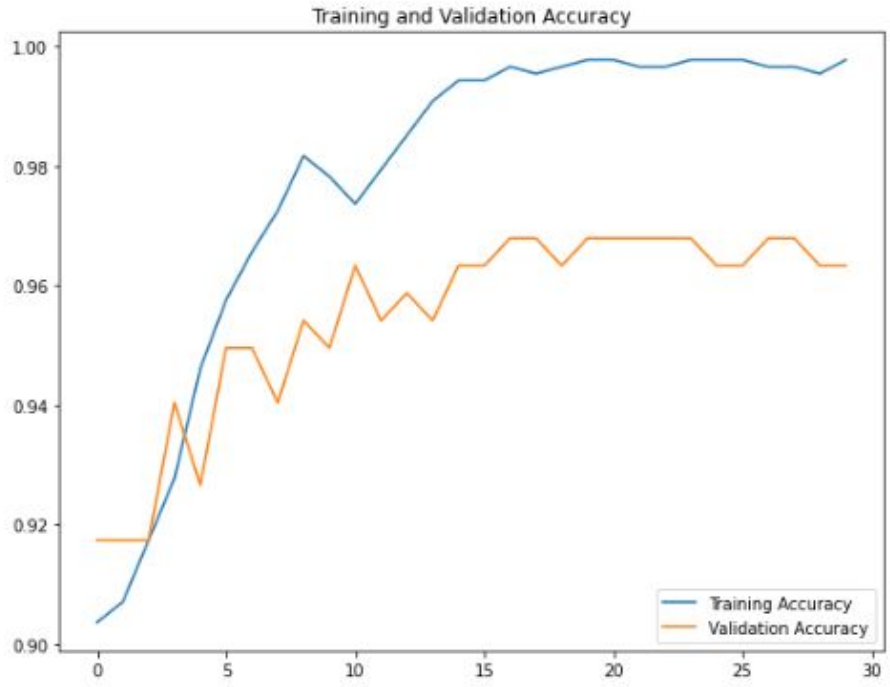

Figure 4.5: Training and Validation Accuracy

Training and validation loss is shown in figure 4.5. Training loss upon training on 30 epochs comes down to 0.65% and validation loss comes down to 24.10%.

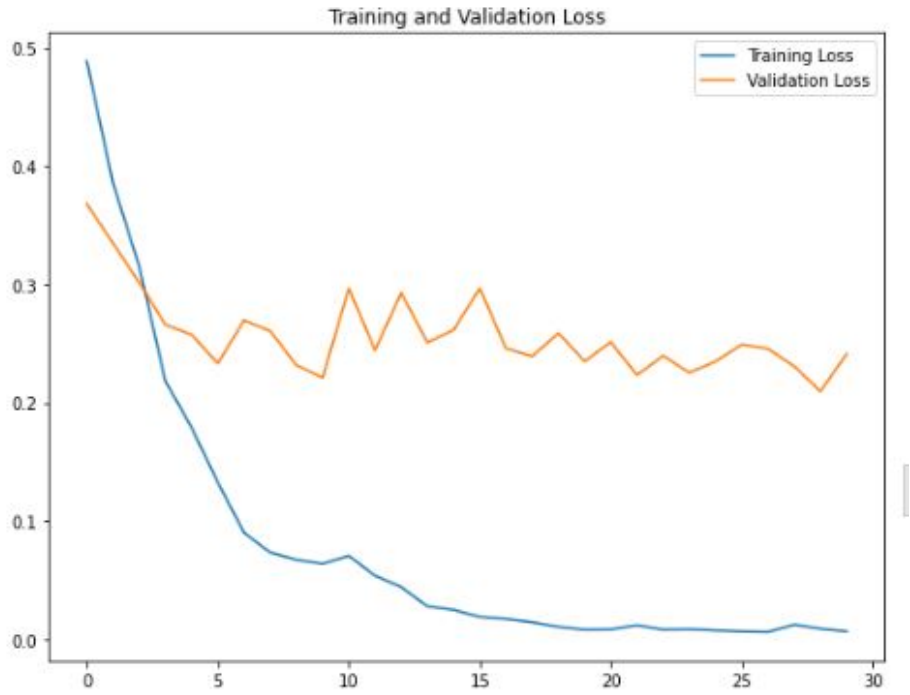

Figure 4.6: Training and Validation Loss

4.6 Make the Prediction

Below image is categorised as 'Money' with a '98.61%' confidence.

Figure 4.7: Money

Below are the predictions made using the model.

Image	Class Predicted	Confidence Percentage
TD72AFBFC6234D5BBE7A43D0728sep.jpg	Card	99.99970197677612
aAE09BFE4405DuC2291D8D1DE6DB9E.jpg	Hacker	99.99902248382568
9719E67F251EF8BFAF5AD516C1rB.png	Device	99.93095397949219
D495oB516F937CD2C811D7AGS_.jpg	Money	98.60568046569824

Figure 4.8: Predictions using the Model

Chapter 5

CONCLUSION

The existing researches have some gaps that is most of them are focused on a specific category of contents, if they consider multiple classes then only some specific classes are addressed, dataset is not available publicly, and image analysis is not confirmed with text analysis. The proposed work aims to address these gaps by classifying dataset into classes belonging to other categories of contents that existing works do not cover, confirming the correlation between textual and image data by classifying images and analysing respective textual contents. A model for identification of category of images has been created and used for identifying the category of test images. A labelled dark web multi-class dataset has been created and will be made publicly available for the academic and research community for future works in this domain.

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