A Review on Graphical Symbols Identification on Food Packages using Machine Learning

Abstract – In the domain of product marketing and labelling, packaging symbols have become a significant part of increasing consumer awareness. When considering food items, several important factors that should be known by consumers. Having good knowledge of these symbols leads to choose the most protective, healthier and suitable food items for themselves. Anyhow with the development of computer technology, automated image classification systems are very popular, especially in symbol recognition. Therefore currently, there are so many research works that are carried on for identifying different kinds of symbols. Artificial Neural Network is one of the most accurate data mining technique and it is widely used in this research works. There are various kinds of neural network techniques that have been used in various existing systems. Here, 15 different proposed systems have been reviewed with analysis of feature extraction techniques and other technologies that have used into a more accurate and efficient symbol recognition system.

***Keywords*— Symbols on food packages, Image classification, Feature Extraction, Artificial Neural Networks (ANN)**

I. INTRODUCTION

Since humans have a wide variety of behavioural patterns, there are nearly 7000 different languages are spoken worldwide. Therefore, human communication has become more complicated ("The International Language of graphical symbols" n.d.). Two individuals can communicate if only they can speak the same language. However, all these barriers have been broken by a simple picture and it has become worth more than a thousand words. There are so many traces that have remained to prove that ancient people were used symbols such as dots, lines, and many other geometric signs to express various ideas and concepts. Even after languages have developed still any language cannot communicate universally as symbols. So, people tend to develop these graphical symbols as a visually perceptible figure with a particular meaning to express some information without regarding the language ("Graphical Symbols, "n.d.). As a result of that today augmentative and alternative communication have been developed and applied in a wide range of areas such as basic communication symbols, scientific and engineering symbols, navigational symbols, hazards symbols, food packaging symbols, safety signs, general consumer signs, etc.

Among all these various kinds of symbols, food packaging symbols have been considering as an important part of product marketing and labelling. In order to convey all significant and necessary information to the general public, product labels have been used these symbols by giving consideration to the increasing consumer awareness for knowledge of what they are buying, consequences of using the relevant product and where the product would be ended up. In addition, today product marketing has been reached to the global market as well. Therefore, growing awareness of the environment has been raised as the prioritized standard when buying and selling any product. Bearing this in mind, symbols of recycling and disposal methods have been introduced.

Figure 1. Symbols on food packages
Source: Internet

By considering this importance, food packaging symbols have been recommended to use by numerous governments and authorities under their relevant laws. According to the Food Act No.26 of 1980, regulations that are relevant to using these symbols have been made by the Sri Lankan government ("Food (Labelling and Advertising) Regulations -1999," n.d.).

Even though the standard symbol set has been introduced as Figure 1, the problem is raised with the unawareness and negligence of consumers. It is harmed to not only human health but also the environment as well. The other problem is even someone wants to learn and recognize these symbols there isn't any convenient method to identify these symbols.

There are many research works the have been done for identification of various types of symbol sets automatically, such as Logo detection, character recognition, musical symbols identification, mathematical symbol identification. and road sign detection systems. However, there aren't previous research works to identify symbols on food packages.

Hence, this paper has been reviewed and analysed about suitable feature extraction techniques and Machine learning techniques for graphical symbol identification by considering related image classification systems that are proposed by different researchers.

II. LITERATURE REVIEW

Symbol classification is one of the popular research problems that has been developing with various Machine Learning and Image Processing techniques. Even though there are no similar research works that have done in previously, to classify symbols on food packages, the following studies were conducted on the classification of different types of symbols according to various applications.

Logo detection is the most related and similar type of research work that has been developed so far. Logo detection and recognition are also important to advertising purposes and quality and copyrights protection in every business product. Gayathri and Akshaya (Gayathri and Akshaya, 2015) have developed a system to identify duplicate logo symbols from original logo by using Scale Invariant Feature Transform (SIFT) along with the multilayer perceptron ANN model to gain high accuracy level and the performance. With this system, they were able to classify logos with corrupted images. However, according to this system, they were not able to detect logos that are contained in videos.

Norzali and others (Hj. Mohd et al., 2008) have proposed a system to detect and recognize the Original 'Halal' symbol by using image processing techniques and ANN. Even though a complete hardware system was not developed with hardware, they have proposed as segments of images were taken by edge detection and shape classification with binary images and then Gaussian Blur effect has used along with the ANN. Although the system accuracy was taken into 91.67%, the algorithm was not much efficient to detect the logo in a crowded background. Noisy images and crowded backgrounds are considered as one of the major challenges for most of symbol classification problems.

As a new approach to a system of noisy logo recognition with "the performance of multilayer perceptron operating as autoassociators to classify symbols" has been proposed by Gori and others(Gori et al., 2003). The main feature of this system is the ability to recognize patterns with "partial obstructions". Therefore, according to this research work a new weighed norm was introduced to measure the input-output accuracy of the neural network and learning algorithm was developed from the backpropagation algorithm (BP). Furthermore, they have developed Edge-backpropagation (E-BP) algorithm in order to increase the effectiveness of the system. Finally, 99.96% recognition accuracy level was obtained for the autoassociators trained with BP.

The researchers (Sahbi et al., 2013) have introduced a logo detection system. This is based on context-dependent, a new class of similarities. In here they have considered about several aspects such as, "the inclusion of the information about the spatial configuration in similarity design as well as visual features, the ability to control the influence of the context and the regularization of the solution via their energy function, the tolerance to different aspects including partial occlusion, makes it suitable to detect both near-duplicate logos as well as logos with some variability in their appearance, and the theoretical groundedness of the matching framework which shows that under the hypothesis of the existence of a reference logo into a test image, the probability of success of matching and detection is high". At last, they have shown system validity with MICC-Logos dataset with CDS matching and detection procedure.

The paper (Zhu and Doermann, 2009) have proposed an approach to logo detection with free segmentation and independent layout logo retrieval in 2D feature point matching. In order to detect logos with different image qualities and dilapidation systems have been developed with “unconstrained setting of a non-rigid shape and demonstrated document images”. In addition, state-of-art shape representations, shape dissimilarity dimensions, shape matching algorithms have been used.

Convolutional Neural Network is one of popular image classification technique that is used for machine learning researches instead of traditional image processing techniques. Bianco et al. (Bianco et al., 2015) have proposed a system for logo recognition using CNN as a robust alternative for low quality images. The proposed system has considered three types of distortions such as blur, noise and lossy compression with the 98% recognition rate.

J.Pradeep and others have presented a handwritten character recognition system without feature extraction in order to less complexity rather than other systems with a 90.19% accuracy rate(Pradeep et al., 2011). Pixel values that have been taken from pre-processed characters of the segmentation process have directly used for neural network training. This character recognition problem is divided into two parts as, handwriting recognition and printed character recognition. The challenge of the printed character recognition is various printed font types.

According to N.Samadiani and H.Hassanpour Self-Organizing Map neural network can be used along with the similarity measure among feature vectors of data for recognising multi-font printed characters. They have achieved a 98.56% accuracy rate for their system without using a large training dataset(Samadiani and Hassanpour, 2015).

Since there are a wide variety of applications, some researchers are focusing on musical symbol classification as the extending problem from character recognition. Even though the form of notation manuscripts or photocopy sheets are still existing in the music industry, music notation computer software will be the next digital step in that field. Here the very first process is recognition of musical symbols from music sheets. There are several machine learning techniques are applied such as support vector machine (SVM), ANN, and k- nearest neighbour (kNN), Hidden Markov models (HMMs), etc. According to A.Robelo and others SVM and kNN are the most suitable techniques for high accuracy systems(Rebelo et al., 2010).

Oh. J et al. have developed an online handwritten music symbol recognition system with the stroke classification technique (Oh et al., 2017). Size information, a histogram of directional movement angles and histogram of undirected movement angles were taken as the main features of the stroke classification. Classifying its strokes and combining them, can be enhanced by an efficient ordering algorithm, according to the music symbols.

Road traffic symbol recognition is another vital application on advanced assistance systems. "Variations in perspective, a variation of illumination, different light levels, fog, occlusions of signs, motion blur and weather-worn deterioration of signs" are challenges in road sign recognition. J.Greenhalgh and M.Mirmehdi have proposed a real-time detection and recognition of road traffic signs system with the detection method of maximally stable extremal regions (MSERs) to unconcern illumination variations and lighting conditions(Greenhalgh and Mirmehdi, 2012). Histogram of gradient (HOG) feature and SVM classifier are used for sign recognition with an accuracy of 89.2%.
A system for offline traffic sign detection in static images using the Matlab Image Processing toolbox has been developed by M. A. Garcia and others. 172 x 352 colour images in RGB (Red, Green, and Blue) format have been used for this vision-based system. Initially, the gradient image and its vertical edge projection is taken according to the algorithm. Then the next step is colours and shapes analysis. Prohibition, warning, obligation and informative are for main types of traffic signs. Each of these four types of signs can be recognised with their different shapes and colours. RGB colour space has been taken for the traffic sign segmentation because it will allow to more efficient detection process(Garcia et al., 2003).

Since the advancement of Deep Neural Network (DNN) D.Ciresan and others has been presented a traffic sign classification system by using DNN with the 99.46% recognition rate(Cireşan et al., 2012). Even though traffic signs in realistic scenes were not localized and classified, “fully parameterizable GPU implementation and Multi Column DNN” were used for the improvement of the performances.

III. METHODOLOGY

Image classification is one of the popular topics in today's research works. However, symbol classification is not much common research as much as logo detection.

Graphical symbols on food packages recognition slightly challenging than logo detection because, even though the same symbol, they are printed in different colours, different sizes and it may have different shapes in different labels.

After selecting a topic for the research, initial information about related works for this research that have collected already were gathered. Since there aren't the same research works that have been done, related image classification, symbol and sign detection researches have been reviewed. When reading various journal papers and conference papers there were so many approaches and algorithms that have been developed to detect symbols from images.

Each data mining technique has shown different accuracy levels and has purposed the technique depends on each model objective. Few of data mining techniques and feature extraction techniques have been considered as follows. As the first step few feature descriptors were reviewed. Usually, feature descriptors extract unique information with finding reliable matching points. Here several popular detection methods were considered to compute keypoint descriptors for image matching. (Routray et al., 2017).

A. Scale Invariant Feature Transformation (SIFT)

There are four computational stages for detecting distinguishing invariant image features that provide vigorous matching between different views of an image. Scale-space extrema detection, keypoint localization, orientation computation, and keypoint descriptor are four main stages and only the keypoints that are robust enough are allowed to jump to the next stage.

B. Speeded-Up Robust Features (SURF)

It is an extended version of the SIFT descriptor. It requires integral images because it requires fewer operations and efficient processes. There are two stages are called keypoint detection and keypoint description. SURF is a more efficient descriptor that continues the same size of the original images and only varies the filter size.

C. Histogram of Oriented Gradient (HOG)

One of the popular descriptors in Computer Vision and it detects local object shape and aspects by using local intensity gradients distribution. Here this descriptor divides the image into small subparts and creates the histogram of edge orientation. Final descriptor is represented as a vector by including stacked histogram results.

Then, several data mining techniques were considered as follows.

D. Naïve Bayesian Classifier

This algorithm based on Bayes theorem which calculates probability by counting the frequency and combination of values. Here, small amount of training data for the relevant classification is required.

E. Decision Tree

It is one of a simple algorithm to divide up a large data collection into smaller sets of simple decision rules. Iterative Dichotomiser 3 (ID3) is an algorithm that is used often. The J48 decision tree is the implementation of the ID3 algorithm.

F. Genetic Algorithm (GA)

Optimized solutions and search problems are provided by using inheritance, mutation, selection, and crossover. There should be a genetic representation of the solution domain and a fitness function to evaluate the solutions.

G. Neural Networks (NN)

It is a tool that is used for complex classifications and clustering. NN is a parallel, distributed information processing structure. Processing elements or nodes and unidirectional signal channels or connections have consisted of NNs. There are two modes in ANN. One is activation transfer mode while the other one is learning mode. When considering this learning technique there are two main types (Mokashi A.R, et al, 2015).

1) Supervised learning: It is a simple model. An output is computed to each input and it is compared with intended value. If the output value differs from the intended value, then the weights of the network are modified according to a learning rule. Single-layer perceptron, MLP, SVM, Decision Tree are examples for supervised learning NNs.

2) Unsupervised learning: In here networks are learned by Identifying specific features in the problem. Self-organizing feature maps is one example of it.

Nonlinearity, fast learning ability, Input-Output mapping, fast adaptivity evidential response, fault tolerance, neurological analogy, and real-time operation are some of the specific features of neural networks. Therefore, these neural network techniques are widely used in the medical field for decision-making processes.

So that, neural network methods that are used in the heart disease prediction has been decided to review. After that, different research papers that are proposed heart disease prediction systems by using various ANN

methods were gathered. Here, 16 different systems were selected to do this review.

The objectives of the model, techniques of the model, number of attributes, accuracy level, and other statistical representations were reviewed according to each system. Also, each model's advantages and limitations were considered. Finally, features should have developed in the future and type of the system which is going to propose has been decided.

IV. FINDINGS AND ANALYSIS

Basic research problem evaluation and brief comparison and analysis of reviewed systems have been represented in this section. A survey on the identification of graphical symbols was held as the initial finding of this research to analyse this research problem moreover and to measure the ability of symbol identification of the general public. This Google form questionnaire-based survey was collected 56 responses. It consisted of 28 different symbols on food packages as well as symbols on the vehicle dashboard to identify for the respondents. According to the responses, respondents were related to every category of age groups under both gender types.

The total mark of the questionnaire was assigned as 28 since there are 28 symbols. When considering about total average of identification of symbols 12.39 is the average mark out of total 28 marks. That means it is lower than half of the total mark as well. The median point is 12 and the overall range of correct total responses is 4-21. Therefore, the first conclusion of this analysis is the general public has a low ability to identify these two types of symbols.

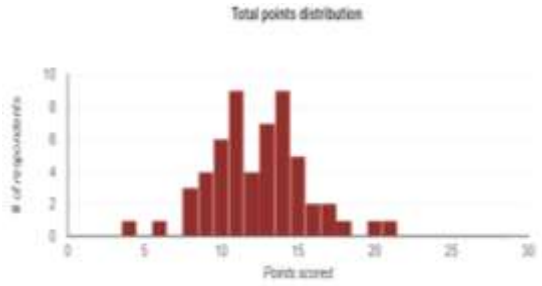

Figure 2. Total average identification of symbols on the survey
Source: Survey Results

As the next step, each question was analysed. In here lowest number correct responses were considered. The number of correct responses of three questions has been taken less than ten correct responses from overall responses. The important point is all these three questions are symbols on food packages. In addition, a smaller number of correct responses were taken to the food packages symbols than vehicle dashboard symbols. Finally, this survey conclusion is symbols on food packages are the most difficult symbol type to the identification.

The next step is the analysis of each system and their techniques that have been used. In order to achieve the most accurate and efficient system this must be most important, as well as the main target of this review. A brief comparison between some systems is shown in the following table 1.

Table 1. Comparison of reviewed systems using ML techniques

Ref.	Symbol type	Image processing	Feature Extraction	Classifier type	Accuracy rate
Hj. Mohd et al., 2008	'Halal' logo	Gaussian blur effect	-	ANN	91.67%
Gori et al., 2003	Noisy logo	-	-	Modified BPNN	99.96%
Bianco et al., 2015	Logo	-	-	CNN	PM(p)-91% PM+QE(r)-63%
Pradeep et al., 2011	Hand writing	Morphological operations, Binarization ,Segmentation	Without Feature extraction	ANN	90.19%
Samadiani and Hassanpour, 2015	Multi-font, printed English characters	Median filter, Normalization	Whisking data in the direction of row and column	SOM Neural Network	98.56%

Rebelo et al., 2010	Handwritten musical symbols		Segmentation	SVM	With ED-98% Without ED-98%

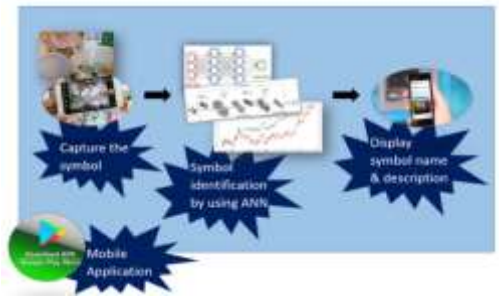

Figure 3. Methodology of the proposed solution

Source: Survey Results

Oh et al., 2017	Handwritten musical symbols	–	HUA, HDA, SI	SVM	92.40%
Garcia et al., 2003	Traffic symbols	Binarization, MSER	HOG	SVM	89.2%
Cireşan et al., 2012	Traffic signs	–	–	DNN	99.46%

V. PROPOSE SYSTEM

In order to obtain a proper idea and knowledge of these symbols on food packages, this research work will propose an Android mobile application that identifies common symbols on food items. It will take an image of a particular symbol as an input of the system. Then it will recognize the symbol and will provide the purpose and the meaning of the symbol. The main expected output of this research is user-friendly, fast, accurate, secure, customize and quality mobile application. Further, it can be commercialized by introducing to Google App Store. This system will identify images with a wide range of perspectives, a wide range of illumination, under different light levels, different occlusions of symbols, motion blur and different deteriorations of symbols. The novelty of this solution is there aren't developed systems to identify symbols on food packages in previously. Besides, there aren't adverse ethical impact or social impact and security threat from this mobile application for any individual or group of people. The final proposed solution can be summarised as the following figure.

VI. CONCLUSION

To create highly accurate, efficient detection system of graphical symbols on food packages, this paper has been reviewed image classification techniques including feature extraction and machine learning techniques. Even though there are so many sign detection and related image classification researches have been done already, there aren't existing system to detect symbols on food packages. Therefore, this paper has been collected some related researches for this review. In most of these existing related researches, artificial neural networks have been enhanced the accuracy (above 80%) of the symbol detection, here a new system has been proposed by using neural networks with analysing factors that can be effected according to this symbol type. The potential benefit of developing this system is increasing public awareness of these symbols to improve consumer habits. Moreover, to provide a convenient way to aware of these symbols and improve the systematic garbage disposal method for environmental protection.

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