DESIGN AND DEVELOPMENT OF AUTOMATED STORAGE AND RETRIEVAL SYSTEM(AS/RS) FOR SPARE PARTS

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Abstract: The storage is an important aspect of any manufacturing facility to store the raw material, tools, machine components, work in progress parts, finished jobs and other required material. The storage room or the warehouses of big manufacturing companies are spread in huge area. Large warehouses are spread in millions of square meter and large variety of products is stored in them. The transaction of parts in the warehouse service provider facility is very high. The manually locating the parts storage, placing and retrieving are very time consuming and hectic job. In such scenario the automatic storage and retrieval system is necessity and very highly recommended technology. Generally technologies like Barcode reader and RFID are used to detect part and its location in the storage rack for picking and placing the item. Machine learning and Deep Learning method to recognize the part is not very widely used. The Alexnet Convolutional Neural Network is used to classify three parts as Nut, Bolt and Washer. System recognizes the part with good accuracy.

Keywords: Design, Automated Storage and Retrieval System (AS/RS),Alexnet, Deep Learning CNN, Image Classification, MATLAB, StorageRack , Bin, Nut, Bolt, Washer.

I. INTRODCTION

1.1 Introduction to AS/RS

Automated Storage and Retrieval System can be defined as the mechanism which is used to store and retrieve items. It is employed to increase the accuracy and speed of transaction [2]. In industry 4.0 warehouses are moving to automated processes of material handling where it has increased the capacity of warehouse while having same physical assets and reduced overall cost [3]. There are disadvantages in using manual material handling such as Human errors, fatigue and boredom to the routine job [5]. Automated storage and retrieval system are commonly used in automated factories, distribution centers, non –manufacturing facilities and warehouses etc. Conveyors belts, pallets handling machines or AGV can be the part of AS/RS system [6]. The AS/RS system has storage and retrieval mechanism, central computer system, storage shelves, storage and retrieval station [8]. It is also one of the important systems involved in flexible manufacturing system. Other FMS components like AGV, Image processing, Enterprise resource planning, Factory Visualization System are also used together [9].

1.2 Applications of AS/RS

AS/RS systems are used in warehouses, Automated Factories and Production facilities. AS/RS can also be used in supermarkets [10].However the cost of AS/RS system is very high so many small and medium enterprises cannot afford it [11].The AS/RS is used in production facilities to store raw material, work in process items and finished jobs. The AS/RS is widely used in high production industry like Automobile industry. Large assembly plant use large AS/RS. It can alsoserveas buffer storage, just in time and kiting of parts for assembly. AS/RS can support computer controlled tracking of material and support factory wide automation [20].

1.3 Technologies used in AS/RS

There are various technologies used in Automation of AS/RS system. RFID tags are used to detect the item and its designated storage cells and for the simulation of AS/RS ANOVA software [1]. New technologies like IOT can also be employed in the AS/RS. IOT device can be used to collect data and send it on cloud for the remote monitoring and remote control [2]. Image processing with MATLAB and artificial intelligence is also used in AS/RS where AGV's are used for material handling [4]. PLC is one of the most widely used automation technology in AS/RS[5]. For the applications like book storage in automated library micro controllers such as ATMEGA 328 is used. For electronics simulation PROTEUS ISIS and for the GUI .NET technologies are used [6].

1.4 Introduction Image Recognition

Computer vision techniques mimicking human vision system are being developed by researchers working in many computer vision and AI based research projects. Image recognition technique is method to recognize given image based on the training of image recognition algorithm. These algorithms work similar to the human vision and brain system. The images were first shown to the vision system and neural network is trained with their respective names, labels or class. Then new image is shown to the vision system and neural networks predict name, label or class of the shown image. This is system is further developed as Machine Learning, Deep learning, Supervised Learning, Unsupervised Learning and Reinforcement Learning etc.

1.5 Image Recognition in AS/RS

The material handling systems with the help of AGV's in the automated warehouses are incorporated with computer vision. The MATLAB is used for the image processing and edge and orientation of the pallet detection. The algorithm is developed to detect the orientation, distance and type of the pallet. The AGV moves automatically and picks up the pallet

[4]. The TCS300 sensor with Arduino Uno controller is used to detect the color and sorting algorithms are used to sort different colors of marbles and stored at their designated places [5]. Automatic pallet detection is used to guide forklift towards the pallet. The system incorporates adaptive structure feature (ASF) and direction weighted overlapping (DWO) method to detect object. The monocular machine vision system removes all kinds of dynamic objects from the picture. This helps to detect stationary pallet more accurately [11].

II. LITERATURE SURVEY

Literature survey is done based on AS/RS system and technologies used in AS/RS system. The design and fabrication of the AS/RS is explored. The Automation techniques, new trends and technologies were surveyed for much better understanding.The use of image processing in AS/RS is surveyed.

S.A. Soundattikar (2019)[4] discussed The advancements in the AGV navigation and vehicle guidance system the AGV's can provide flexibility and agility in small and medium industries. The computer vision system with artificial intelligence and adaptive automaton is the focus of the paper. The AGV is selected for single load application to grip different size diameters cylindrical objects. The image processing and edge detection is done through MATLAB software.

SumarduSadi (2018)[5] developed The prototype of the Automatic filling of the marbles in the container with different colours and heights is made. This employs Arduinouno with TCS3200 sensor to detect colours like Red, Yellow and Red and also detects the height of the container. The IR sensor is used to count number of marbles falling into the container and LDR is used to control the motion of the conveyor. Instead of the TCS3200 sensor we can use camera and image processing to detect colour and the height of the container.

Gang Chen (2012)[16] proposes a image processing method to locate the pallet and the distance of the forklift from the pallet in this paper. The author proposes to convert RGB image to HSV and YUV. Then applying kalman filter the speed of image processing could be increased. The processed image is converted into monocular pattern. Using SUSAN method the edges of the image are detected. While taking the image sonar is employed so the distance from the pallet of the forklift is determined. The results of the distance between pallet and the forklift are compared with Kalman filter and camera mode. The experimental results confirm the method is accurate. This kind of image processing can be used to detect shape of the object.

O. V. KrishnaiahChetty (2003)[18] discussed about the genetic algorithm application in AS/RS scheduling. As generally first come first serve method is used. The genetic algorithm is developed if there are number of requests are more than one. The different rules of scheduling such as SPT, RANDOM, NNH, MWKR and FCFS are compared with GA with respect to the no of S/R requests are serviced. The results show that AS/RS with GA works better than other scheduling rule.

SungminByun (2008)[19] developed monocular vision based system is to detect the pallets, its position and orientation. The author suggest that when image is taken and its features are extracted to detect the pallet. The back projection of the image is taken. When the edges of the image are parallel to the back projection of the image then the face of the pallet and forklift is in line. This method of finding the orientation of the pallet and adjusting according to the face of the pallet can avoid accidents and idle time orient incorrectly oriented objects on conveyor

The ML and Deep Learning technologies are not very widely used in AS/RS. The object classification using ML and Deep Learning can be done to store and retrieve the spare parts from the storage rack.

III. METHODLOGY

The methodology for the research work is discussed in this topic. The workflow diagram and process flow diagram are explained.

3.1 Worklow Diagram

The literature survey was done for the design and development of AS/RS for spare parts and for recognition of spare parts. The Alexnet Deep CNN is used for spare parts recognition. The data set of spare parts was created by downloading images of Nut, Bolt and Washer from Google. Few images were manually taken using mobile phone camera keeping background of image white in different angles and orientations. The network was trained using data set and tested with new images. If the accuracy of tested images was not satisfactory the network was trained again with test images and again new images were tested.

This process repeated until the required accuracy of prediction is achieved. The new images further tested to check the accuracy. The obtained results were satisfactory and observations were tabulated and conclusions were drawn as per the observations and results.

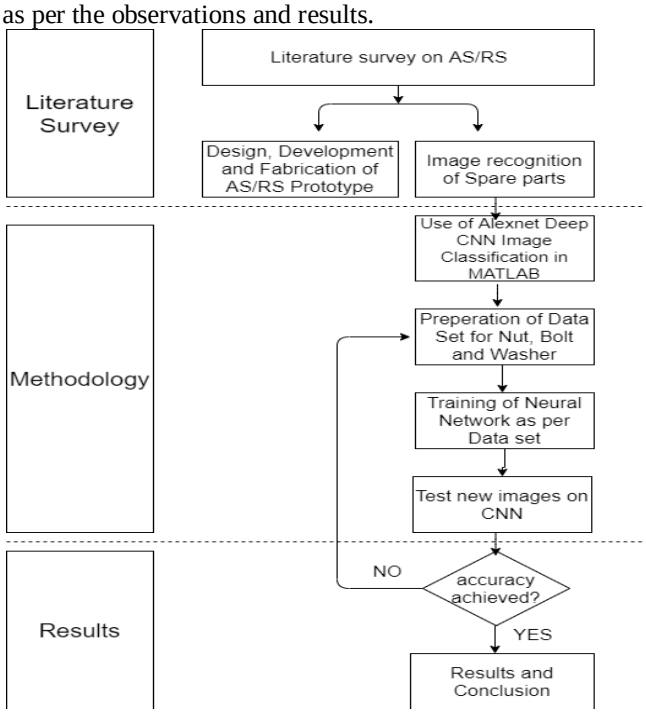

Figure: - Work Flow Chart

3.2 Process Flow Diagram for Image Recognition

The process flow diagram shows the image recognition process of spare parts using Alexnet Deep CNN. The spare part recognition system works on Alex net deep CNN. The alexnet uses RGB image and converts it into 257X257 images. Then this image is processed using Max pooling,
Data Augmentation, Nonlinear ReLU, Overlapping, and Reduced over fitting, Softmax classifier and drop out method etc. It uses total 8 layers to train the network. It uses 5 convolutional network and 3 fully connected layers. To train network we need train and Test data set. Data set of Nut, Bolt and washer was created. These images are collected from the Google. They are stored in the laptop in the folder data set in sub folders named as 1, 2 and 3. The network uses this data set to train ad test the network. After completing the training process we can use new image for image classification. New image can be introduced by capturing image using a webcam or the image can be stored in the laptop and location of the image is provided to the network to test it. The image classifier recognizes the image and then the result is printed as Nut, Bolt or Washer.

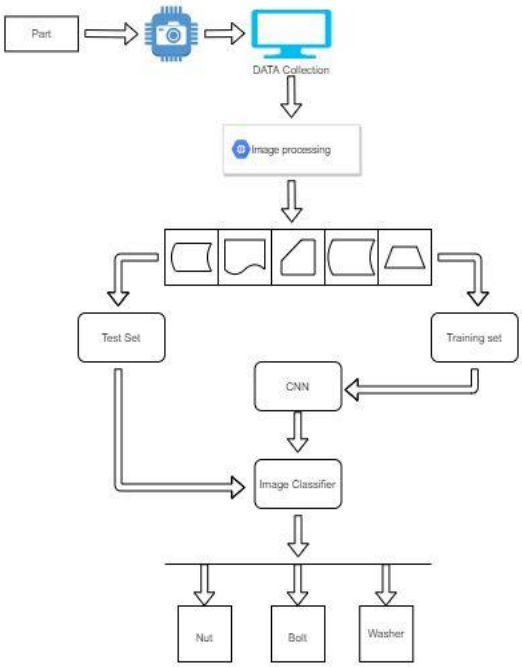

Figure: -Image Recognition Process Flow Chart

The proposed design of prototype has two axes X and Z axes. The length of X axes leads screw is 500 mm and Y axes lead screw has length of 100 mm. The rack 330 mm in length and each cell is has length of 100 mm. The bin size is 30 mm3sizes. The bin weight is 100 gram with the spare parts. So the maximum payload is 100 gram.

3.3 Alexnet.

Alex Krizhevsky and IlyaSustkever [12] published a research paper titled as 'ImageNet Classification with Deep Convolutional Neural Networks' in 2107. In this research they trained 1.2 million high resolution images into 1000 different classes. The error rates were 17%. They trained a neural network which had 60 million parameters, 650,000 neurons consist of five convolutional layers, some which were followed by max-pooling layers. Three fully connected layers with final 1000 -way softmax. To make faster training they used non-saturating neurons. They implemented GPU very efficiently. To reduce over fitting they used 'dropout' method which turned out to be very effective. The alexnet won over the Microsoft Research Asia' deep CNN which is 100 layers deep. Alex Krizhevsky won that competition in 2015. Since the inception of Alexnet it has been used by researcers for in their Machine Learning and Deep learning research projects.

IV. IMPLEMENTATION CASE STUDY.

The deep learning CNN requires the data set. The data set is divided into test and Train data. For the application I needed images of Nut, Bolt and washer. I collected the images from internet. As there is no such data set available. I downloaded images from Google one by one. I created the data set from the downloaded images around 120 images for each class. It was very time consuming process.
The stored images are sorted and saved into three distinct folders in the folder named as data set. The three sub folders are named as 1, 2 and 3 [21].

Figure: - Dataset for Washer

Figure: - Dataset for Washer

Figure: - Dataset for Bolt

The path of the store data set is given to the code. The code initializes and it resizes all the images in 227X227 pixel image sizes. It also labels the image. It divides the Train and Test data in 80% and 20% respectively.

Code then trains the neural network using training data. The alexnet is called by the function alexnet. The layers of the network are set. The code further trains the netwro with 0.0001 learning rate. The code runs the 5 epochs and does 20 iterations each. While network is being rained the graph of accuracy and loss is plotted in real time.

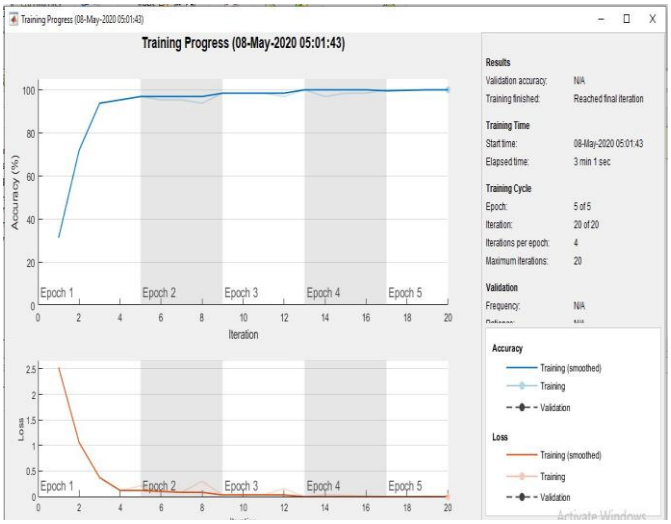

Figure: - Real time graph Accuracy VS iterations and Loss Vs. iterations

Further code runs to test the accuracy of the Neural network. It uses classify function to classify the images. The images are predicted and name is assigned to the predictions. The row vector is the created using size function. This row vector is used to calculate the accuracy of the test data. The accuracy of neural network is printed as shown below

```
Training on single CPU.
Initializing input data normalization.
|=========================================================================================|
|  Epoch  |  Iteration  |  Time Elapsed  |  Mini-batch  |  Mini-batch  |  Base Learning  |
|         |             |   (hh:mm:ss)   |   Accuracy   |     Loss     |      Rate       |
|=========================================================================================|
|       1 |           1 |       00:00:10 |       31.25% |       2.5251 |    1.0000e-04 |
|       5 |          20 |       00:03:01 |      100.00% |       0.0001 |    1.0000e-04 |
|=========================================================================================|
Program paused. Press enter to continue.
Predicting accuracy for Test Set
The accuracy of the test set is 97.333333
```

Figure: - Accuracy of test set

After testing the data now it's time to check the accuracy of the neural network. To check the neural network accuracy the new image of part is stored. The path of this stored image is given to the imread function. The code then resizes the new image in 227X227 pixel by using function resize. Then Classify function is used to classify the image as per the class. When image is classified as '01' the answer is printed as Bolt, when image is classified as '02' the answer is printed as Nut and when image is classified as class '03' answer is printed as Washer.

V. RESULTS AND DISCUSSIONS.

The Image recognition algorithm is tested on the new test images. These images were taken keeping background white in color. 14 different images with different orientations were taken for each class. Total of 42 images were tested for image classification. The observations are tabulated below.

Table: - Test Set Prediction

Sr. No	Sample size	Manual Classification	Classification by Code	
			True	False
1	14	Washer	13	1
2	14	Bolt	13	1
3	14	Nut	13	1

Table: - The Test Classification Results

VI. CONCLUSIONS

The Alexnet is used for the image recognition in this project. There are three classes of the objects such as Nut, Bolt and Washer. The images were initially downloaded from internet and some images were taken manually using mobile phone camera and included in data set. Data set of the images was created for training and testing. The Alexnet neural network was training using this data set. This neural network was tested with new images and the accuracy of prediction of the image class is 92.85%. The deep learning image recognition process is not very widely used in the AS/RS system to identify the object and to pick and place the object. This method can be utilized in the AS/RS system. The Natural Language Processing can be integrated to call objects from the cell using voice commands. This application can be used in small stores. The AS/RS can be used in medical stores to pick and place the medicine by processing the image of doctor's hand written prescriptions using text identification by deep learning. The N number of object classes can be created using Alexnet in MATLAB

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