Yash Rohera | Manas Dedhia | Rohit Mahatme
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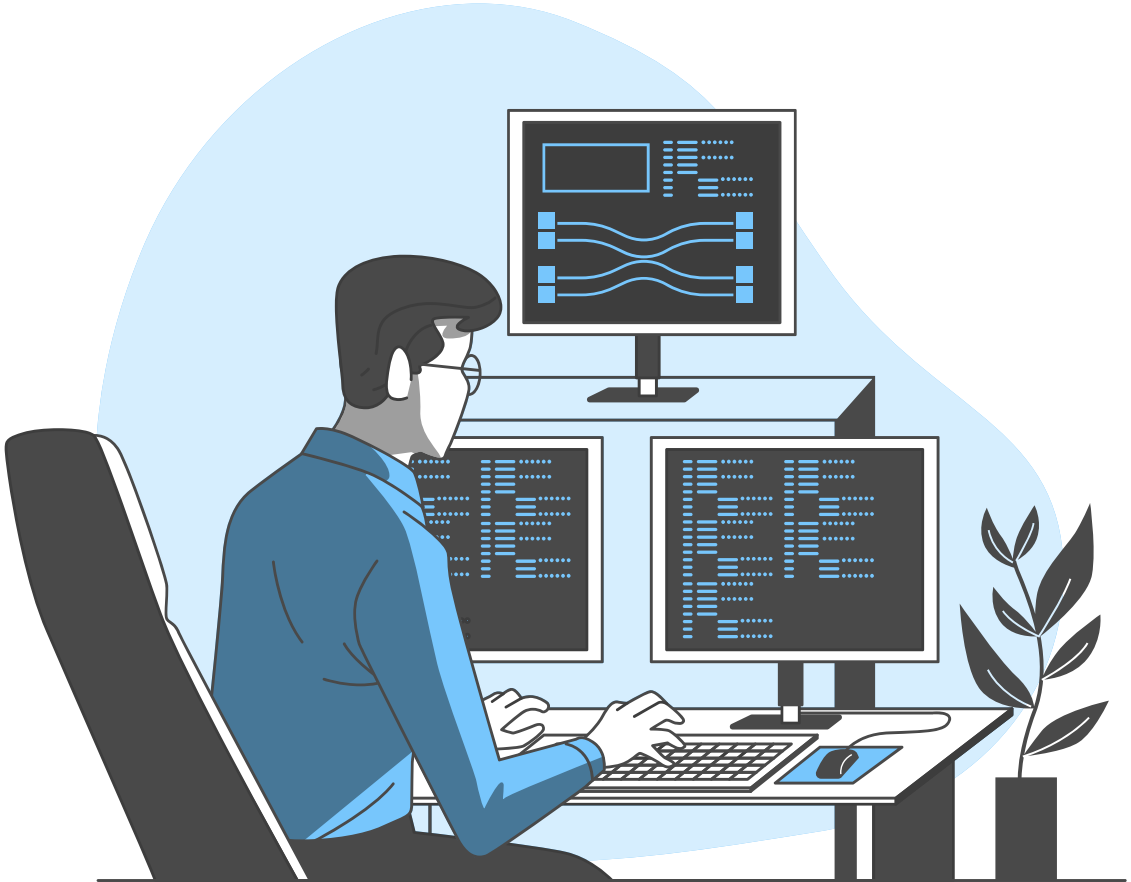
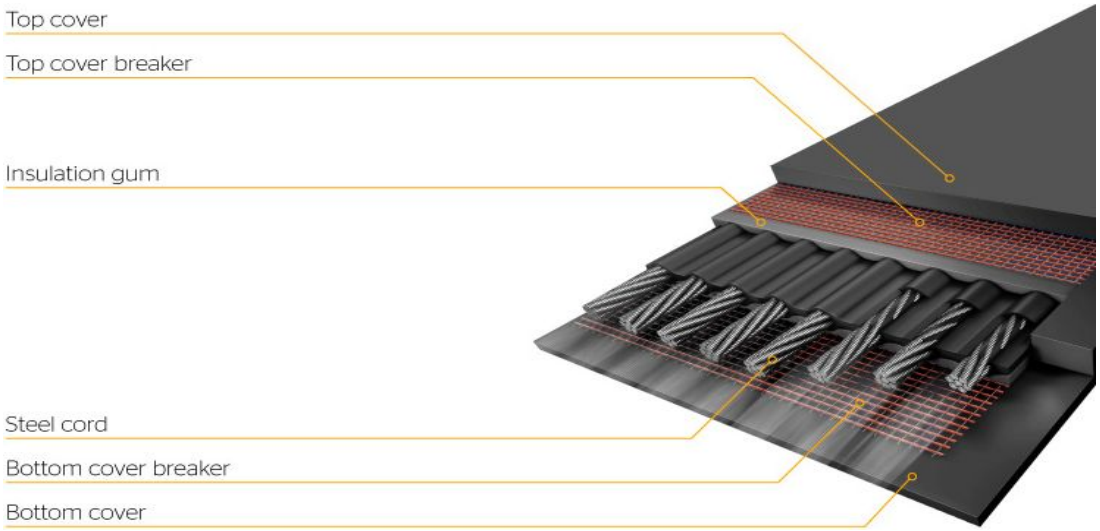


Automated Belt Fault Detection System

Using advanced Machine Learning and Image Processing to automate fault detection in belts

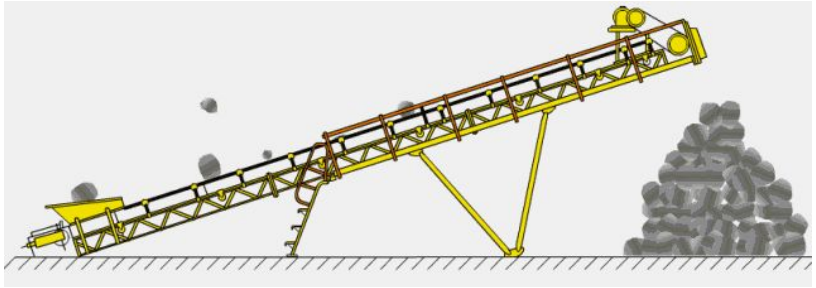
What is a conveyor system?



A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transport of heavy or bulky materials. As the widely used mechanical transportation equipment, the belt conveyor plays a critical role in transporting material in mining and other industries

Working of conveyor belts

- Typically, conveyor systems consist of a belt stretched across two or more pulleys. The belt forms a closed loop around the pulleys so it can continually rotate.
- One pulley, known as the drive pulley, drives or tows the belt, moving items from one location to another.
- The most common conveyor system designs use a rotor to power the drive pulley and belt. The belt remains attached to the rotor through the friction between the two surfaces.
- For the belt to move effectively, both the drive pulley and idler must run in the same direction, either clockwise or counterclockwise.



Problems faced by conveyor belts

01

Belt Mistracking

Belt mistracking occurs when your belt comes off track from its desired path. Belt mistracking is a serious problem that can lead to belt damage, equipment damage, and material spillage.

02

Material Carryback

Conveyor carryback occurs when small amounts of material adhere to the belt. This can lead to accumulation of material under the conveyor system or buildup on idler rolls and pulleys.

03

Belt Damage

Belt damage can be caused in several ways such as excessive impact forces, mistracking, seized components, and low pulley traction among others. With belts being the most expensive asset of the conveyor, it is critical to identify potential causes.

04

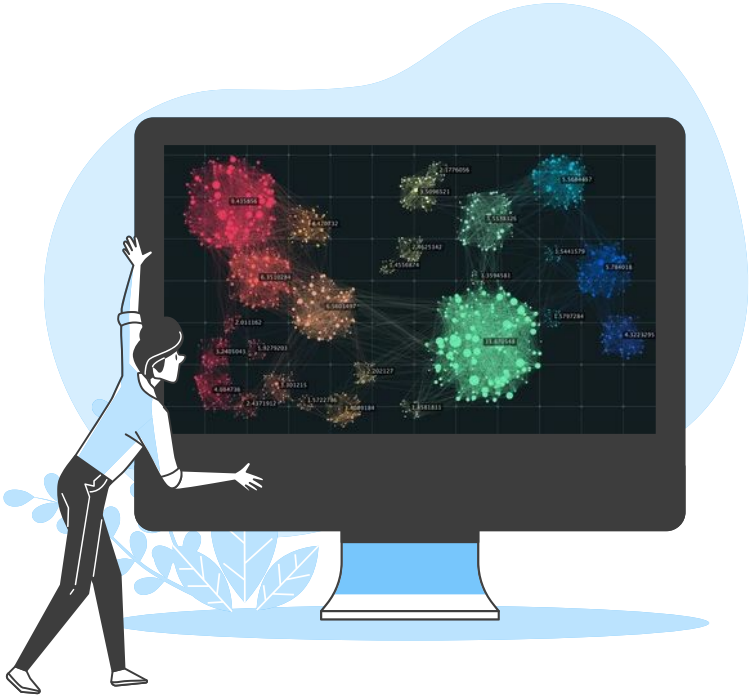
Lack of monitoring

Accidents are mainly caused by not timely detection of the system fault, which compounds difficulties to diagnose the equipment failure in real-time when the fault occurs. There are few fault diagnosis systems for belt conveyors currently, but they aren't efficient.

Our Proposed Solution

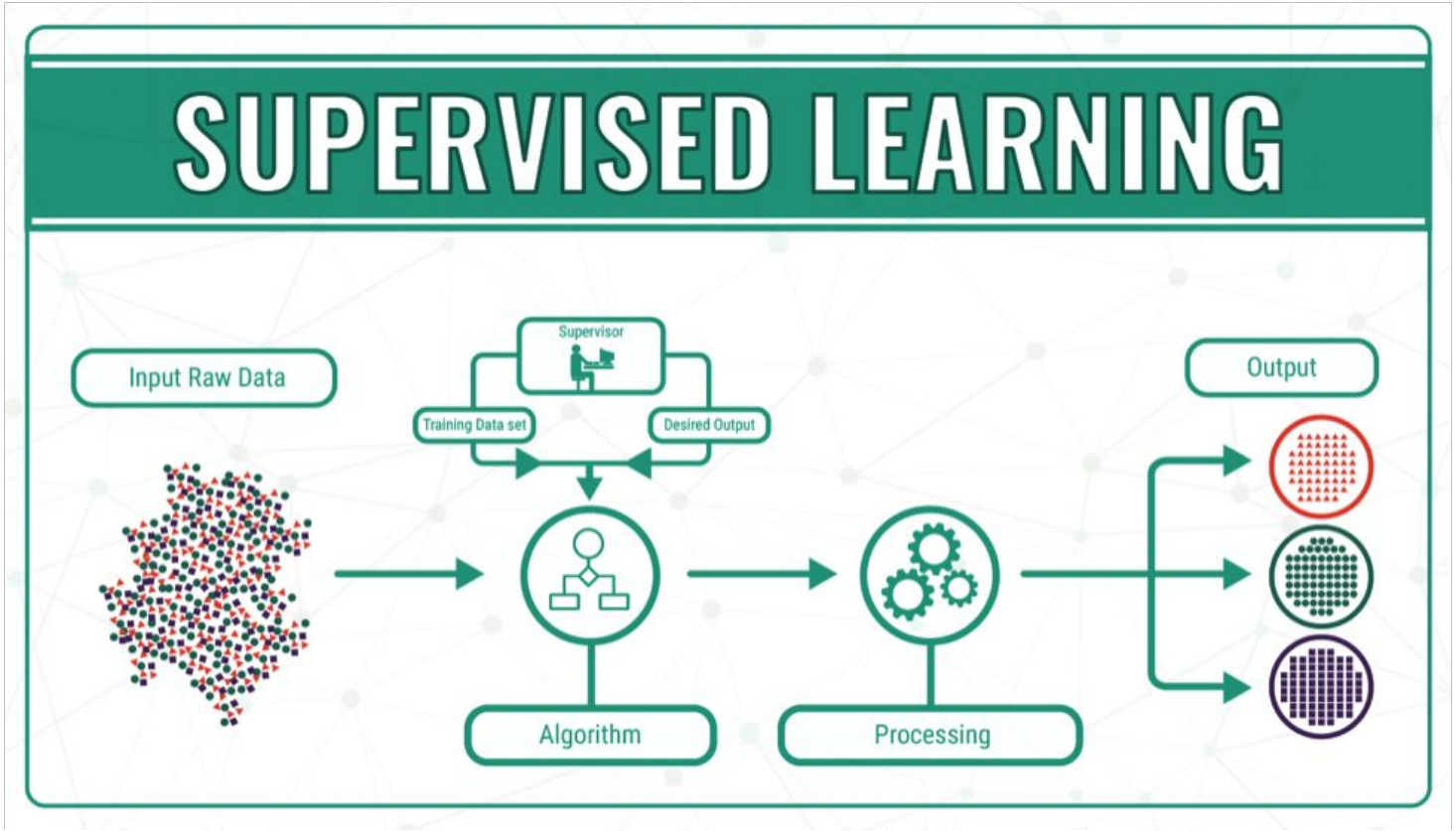
1. One of the issues faced by the conveyor belts is the absence of a system to detect the faults such as cracks, scratches, and tears on the belt in real-time.
2. Such a system could help to detect the faults efficiently and in real-time which could also help in the proper maintenance of the conveyor belt.
3. In this era of IoT, almost all the issues can be solved using ML and AI. With the help of ML, we could easily create a model that can detect the defaults in the belt efficiently and in real-time using advanced Image Processing algorithms

Supervised Machine Learning

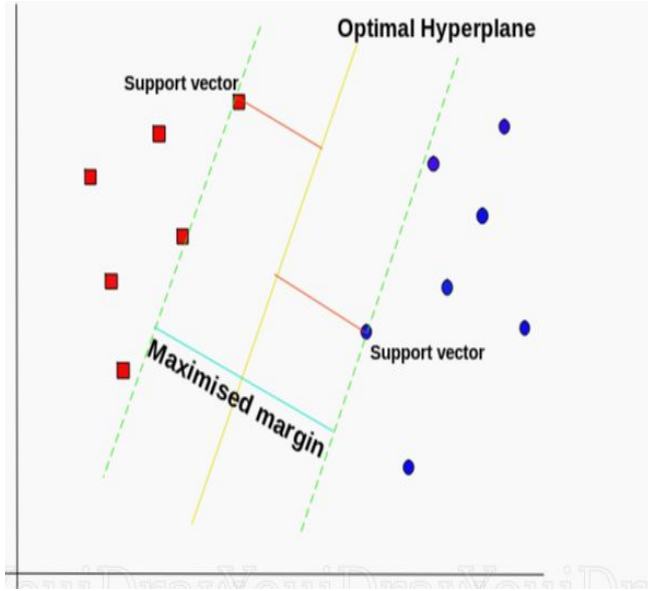


1. Supervised learning is an approach to creating artificial intelligence (AI), where a computer algorithm is trained on input data that has been labeled for a particular output.
2. The model is trained until it can detect the underlying patterns and relationships between the input data and the output labels, enabling it to yield accurate labeling results when presented with never-before-seen data.
3. Supervised learning is good at classification and regression problems, such as determining what category a news article belongs to or predicting the volume of sales for a given future date.

To detect faults in the conveyor belt supervised machine learning algorithms are used in which some labeled input data is rendered to train the ML model and get the desired outputs



Support Vector Machines



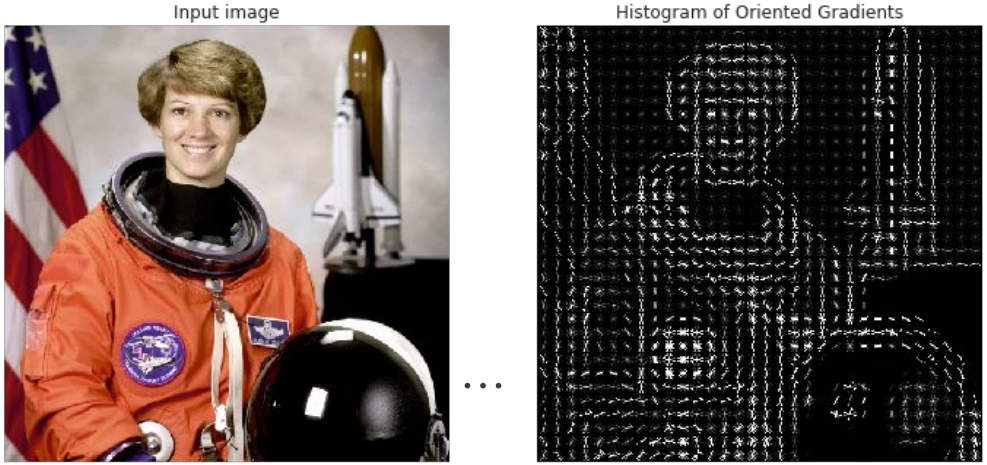
Support Vector Machine (SVM) is a supervised machine learning linear model for classification and regression problems.

- What SVMs do is to find a separating line(or hyperplane) between data of two classes.
- SVM is an algorithm that takes the data as an input and outputs a line that separates those classes if possible.
- According to the SVM, we find the points closest to the line from both classes. Now, we compute the distance between the line and the support vectors.
- Our goal is to maximize the margin. The hyperplane for which the margin is maximum is the optimal hyperplane.

SVM tries to make a decision boundary in such a way that the separation between the two classes (that street) is as wide as possible.

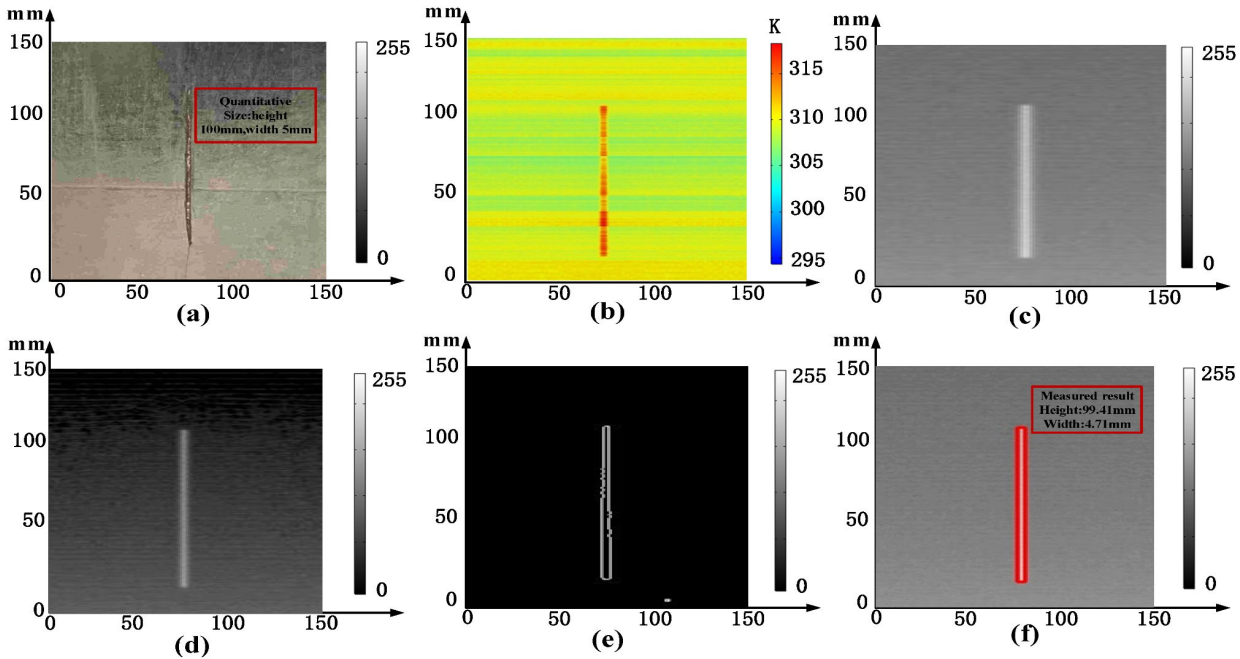
HOG (Histogram of Oriented Gradients)

1. Histogram of Oriented Gradients, also known as HOG, is used in computer vision and image processing for the purpose of object detection
2. The HOG focuses on the structure or the shape of an object. HOG algorithm helps to extract feature descriptors from the image.
3. Feature descriptors simply mean the representation of an image that simply extracts useful information and disregards the unnecessary information from the image.



How to integrate SVM and HOG for a holistic algorithm?

As mentioned in the definition of HOG, the algorithm is used to extract unique features from an image. When an image is passed through an HOG algorithm it detects some common continuous regions in the image.

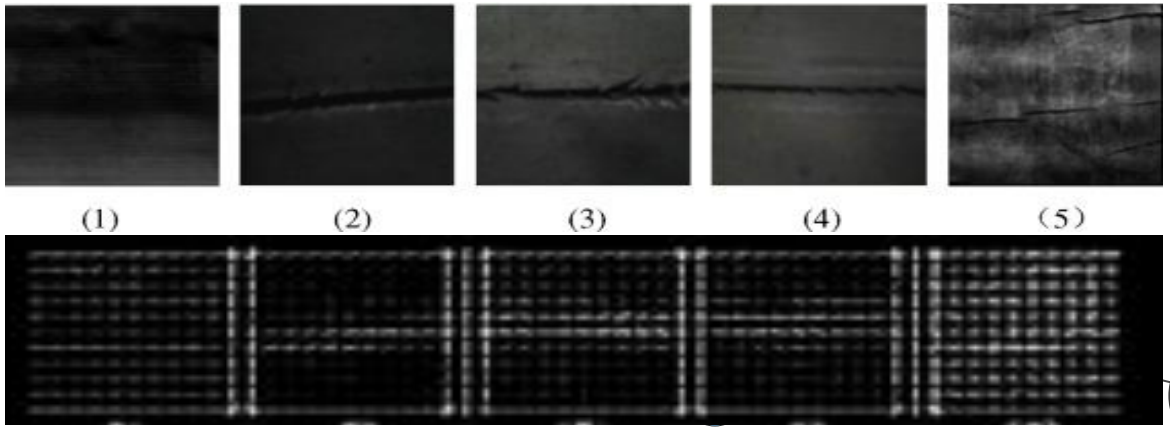


Similarly, when we pass the image of a conveyor belt through the algorithm it detects different defaults as they form some unique continuous regions. The images of these defaults are letter used to train an SVM Machine learning model that could classify the default as scratch, crack or tear

Method to create an efficient database

- First, we collect thousands of images of conveyor belts consisting of defaults. Then we pass them through the HOG algorithm to detect the various defaults and store them as separate images. Below are 5 images that an HOG will detect through the course of a week. Then we label each default image as scratch, tear and crack manually.
- After labeling them nearly 80% of the labeled data is used to train the SVM ML model (training set) and the remaining 20% (test set) is used to calculate the accuracy of the algorithm i.e. it will be fed into the algorithm to check if it provides the correct solution.

Histogram generated by HOG algorithm

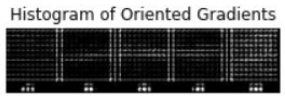


HOG code snippet

```
# import the necessary packages
import matplotlib.pyplot as plt

from skimage.feature import hog
from skimage import exposure

%matplotlib inline
```

```
[ ]  # Dalal and Triggs report that using either 2 x 2 or 3 x 3  cells_per_block  obtains reasonable accuracy in most cases.
     file  ="/content/Picture1.jpg"
     image = plt.imread(file)

     fd, hog_image = hog(image, orientations=15, pixels_per_cell=(10, 10),
                         cells_per_block=(1, 1), visualize=True, block_norm="L1", transform_sqrt=False)
     # display the image
     fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(8, 4), sharex=True, sharey=True)

     # Rescale histogram for better display
     hog_image_rescaled = exposure.rescale_intensity(hog_image, in_range=(0, 5))
     # display the HOG features
     ax2.axis('off')
     ax2.imshow(hog_image_rescaled, cmap=plt.cm.gray)
     ax2.set_title('Histogram of Oriented Gradients')
```

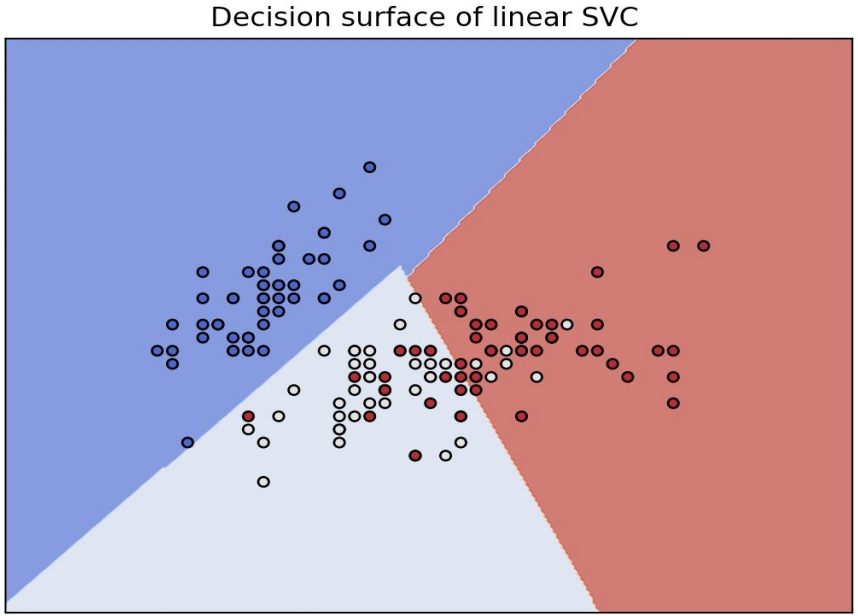
```
Text(0.5, 1.0, 'Histogram of Oriented Gradients')
```



Analysed image displayed in previous slide

How to train the model?

Once the database is created the process of training the model is initiated. Nearly 80% of the labeled data is used for training the model. The training dataset is split into 2 parts x_training_set and y_training_set where x is the default image pixel matrix and y is the type of its default. And as mentioned in the definition, the SVM algorithm takes the data as an input and outputs a line that separates the types of defaults



Since the graph is multidimensional it can't be viewed

Accuracy Calculation?

- After the model is created the rest of the 20% of data is used to calculate the accuracy.
- The test images are passed through the algorithm and the output is compared with the actual value.
- Accuracy score helps us to measure the efficiency of our model and also enables us to change certain parameters

Accuracy: Number of correct output / Total number of test cases

Building a continuous model training system

- Even after getting a good accuracy score, it is possible that the algorithm might give some wrong predictions as all the scratches, cracks and tears are not of the same type.
- To tackle this there is a need to continuously train the model by adding each and every predicted data in the database so that we can acquire more and more data to make our data efficient.
- If a wrong prediction is detected during the maintenance process updating the database with the correct one could improve the model further.

Conclusion

The above-mentioned solution is a very theoretical approach that has been tested on very few images. There is a very big possibility that the model fails on a large scale however the errors can be rectified by passing a large dataset. There are a number of machine learning algorithms that can show better results but to identify the suitable one, there is a need for a large database.

We hope we can continue work on this project to come up with an economical and reliable solution to belt maintenance once we have access to laboratory and practical facilities after the campus fully reopens.

Thanks!

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