Estimation of Cycle Time in Transformer Manufacturing Using a Vision-Based Learning Technique

General Electric

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Project Summary

This project is about the industrial use of computer vision to help automate a small part of the manufacturing process of transformers in the GE factory in Gebze. The goal of the project was to develop a vision algorithm for automatically counting man-hours on the factory floor using digital cameras and also using an image matching algorithm to find the progression status of a manufactured transformer unit. To this end, state-of-the-art algorithms such as YOLO for human detection and ORB features for image matching were used. Results are quite promising and much work needs to be done to fully explore the potential of using computer vision and machine/deep learning.

Motivation

This project aims to develop computer vision algorithms for the automation of the transformer manufacturing process. Starting from a small workspace within the factory (*Figure 1*), a successful result may lead to the automation of the whole factory's manufacturing process. Distinct aspects of computer vision will be used to achieve this goal.

Figure 1: The workplace

Problem Statement

General Electric Transformer Factory in Gebze is scrutinizing ways to use computer vision systems to automate the control mechanism of the manufacturing process within the factory. Currently, it is done manually by the operators, by marking the current progress on a board (*Figure 2*) multiple times a day. This is slowing down the process of manufacturing and introduces human error.

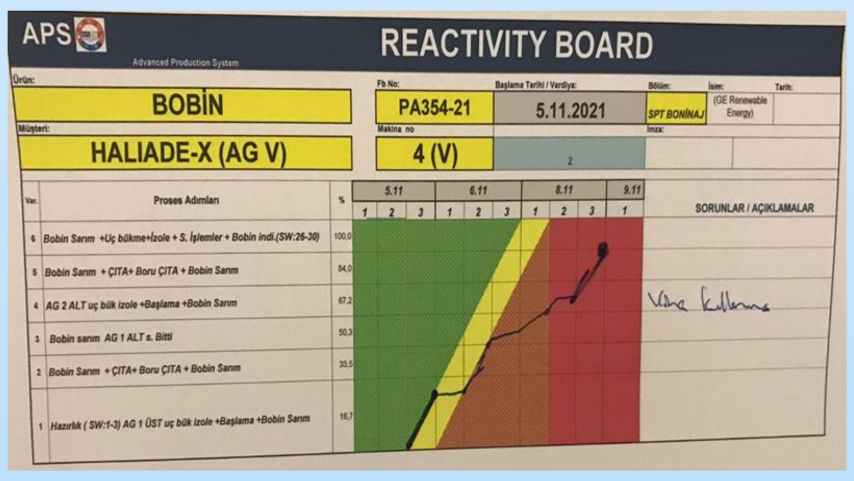

Figure 2: Manually marked board

Figure 3: Bobbin Coiling

The operation done within the workplace is bobbin coiling (*Figure 3*). Using images captured by a digital camera, the main goal of the project is to detect and calculate the human-hours that have been spent on the current product, to detect the completion percentage of the product and to determine if the amount of work done matches the predetermined completion percentage.

Methodology

To be able to detect the total human-hour(s) and completion percentage of the product, different computer vision problems are tackled:

a. To detect the total man-hour(s) spent, human detection algorithms are used. It counts the total hours that a worker spends on the product.

b. To detect the completion percentage of a product, first distinct features within the frame are detected. After extracting the features, the current frame is compared with a predetermined set of images. These sets of images are the images of the product from different timelines and labeled by their completion percentage by the operators from the factory. To be able to perform this comparison, feature matching algorithms are used.

1. Human Detection Algorithm: YOLO (You Only Look Once):

YOLO is a unified, real-time object detection algorithm. It was developed by Joseph Redmon in 2015. In this project, YOLO version 5 has been used. Its main advantages compared with similar algorithms are:

- YOLO is very fast since it approaches the problem as a regression problem.
- YOLO does contextual predictions over the total image; it doesn't use sliding windows but sees the image as a whole.
- YOLO can generalize object classes during training.

2. Feature Matching Algorithm: ORB (Oriented Fast and Rotated Brief):

ORB is based on the efficient, low-cost FAST (Features from Accelerated Segment Test) keypoint detector and the BRIEF (Binary Robust Independent Elementary Features) descriptor. BRIEF descriptor employs simple binary tests to distinguish pixels in an image. FAST algorithm is, as the name implies, a fast algorithm in terms of keypoint detection. It outperforms most of the state-of-art algorithms in terms of speed. BRIEF on the other hand is a state-of-art level descriptor, which performs similar results to one of the best known algorithms, namely the SIFT (Scale-invariant Feature Transform) algorithm.

Experimental Results

Human Detection Results:

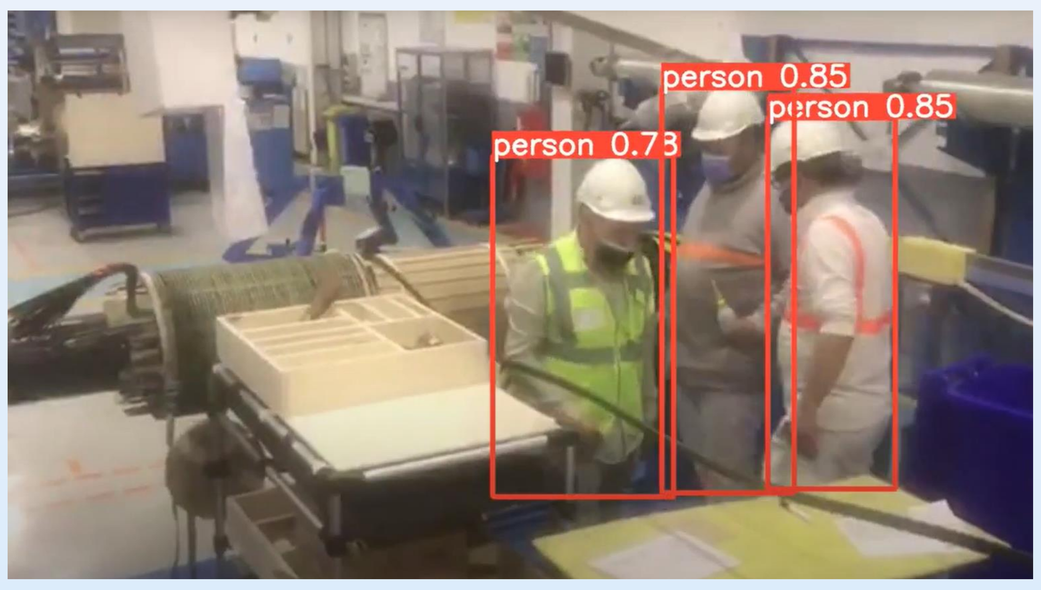

Figure 4: Multiple Human Detection

Figure 5: Occlusion Scenario

The YOLO algorithm can detect humans with nearly 80% confidence within each frame (see Figure 4). In the case of occlusion where people block each other's view (see Figure 5), although the confidence values reduce, it can still detect the humans within the frame. YOLO is feasible to use in real-time applications.

Feature Matching Results:

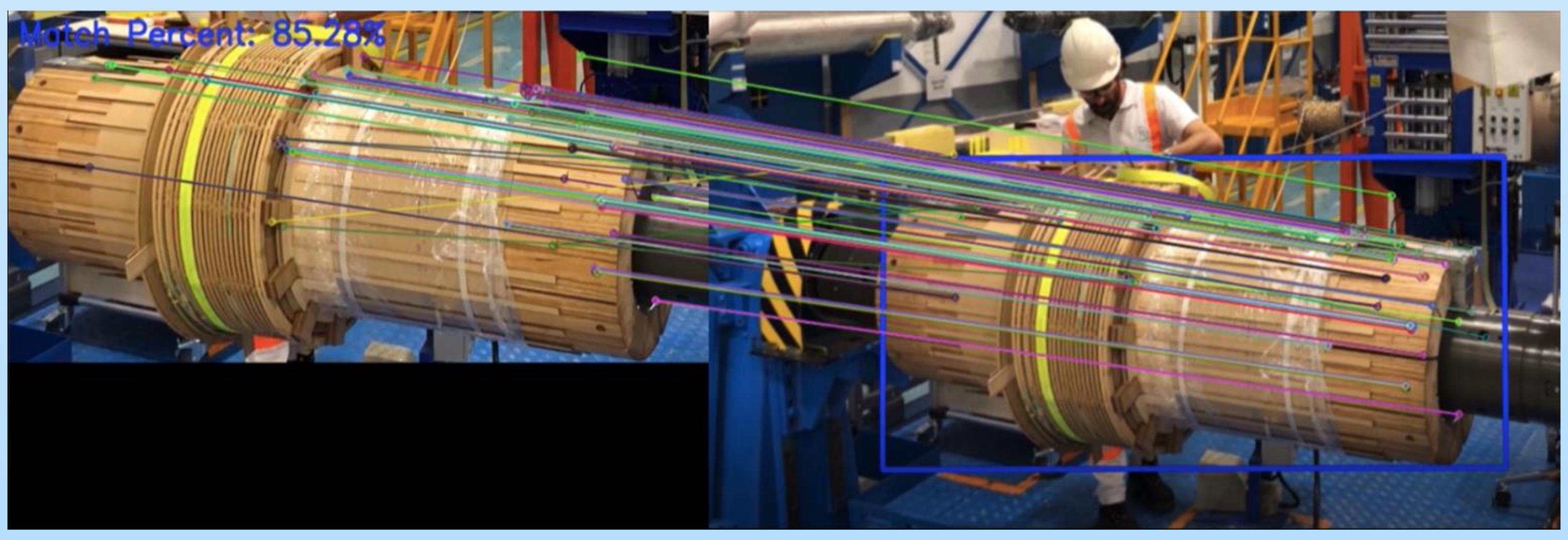

Figure 6: Feature Matching with ORB

The ORB algorithm can match the bobbin within the current frame (on the right) with the reference image (on the left). ORB is giving good results in real-time applications.

Conclusion

The goal of the project was to implement human detection and feature matching algorithms, and investigate if they were feasible in the context of this project. Optimum algorithms have been selected and implemented in real-time. Experimental results are very promising and demonstrate potential of these algorithms in automating part of the transformer manufacturing process.

Future Work

- Both human detection and feature matching algorithms can be improved to work more efficiently.
- Every step of the coiling process needs to be labeled and added to the dataset of reference images, to be able to compare the current completion percentage with the expected completion percentage.
- An interface should be added to the project, stating if the current work is on track or not.

References

1) Naeem, Hammad & Ahmad, Jawad & Tayyab, Muhammad. (2013). *Real-time object detection and tracking. 148-153. 10.1109/INMIC.2013.6731341.*
2) Josué Díaz (June 4, 2019). *Vision: What Are The Advantages And Disadvantages*. *https://www.itexico.com/blog/computer-vision-what-are-the-advantages-and-disadvantages*
3) Karami, Prasad, Shehata. (2017).Image Matching Using SIFT, SURF, BRIEF and ORB: Performance Comparison for Distorted Images. https://arxiv.org/pdf/1710.02726
4) Du, Juan. "Understanding of Object Detection Based on CNN Family and Yolo." *Journal of Physics: Conference Series* 1004 (2018): 012029. https://doi.org/10.1088/1742-6596/1004/1/012029.
5) Redmon, J. (2015). You Only Look Once: Unified, Real-Time Object Detection. arXiv.Org. https://arxiv.org/abs/1506.02640