Case Study

Tire recognition meets Machine Learning

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The Client

We got introduced to our client who for the sake of NDA, we will call Frank. So, Frank is a huge wholesale of tires and distribution center, a B2B business that has deals with many smaller shops who buy and resell their tires.

When the tires arrive to Frank's distribution center, personnel at the center physically examine tires and then sort them. Now, you'd say what's a big deal here- you sort them according to predefined parameters and that's about it.

Well, it is not.

Let's put it this way: Try placing your tires inside of your car trunk. Tough job, isn't it? Tires are not very elegant or designed for optimal storage. They are just- tires. Their purpose is not to fit anything but the vehicle. But that's not really the moral of this story.

Challenge

The Issue they were facing was tire sorting and distribution within their wholesale centers. Frank’s tire catalogue included 80 tire manufacturers and over 20 000 unique tire models, with 5digit number of tires moving daily. Aside from the risk of human error during sorting upon arrival, there was a risk of human error when sorting prior to shipping out.

Our approach included computer vision and conveyor belts, and the job was performed by five people from our side.

Modus Operandi I

Step 1. DATA EXTRACTION

Our goal was to EXTRACT THE DATA from the tire. Data that we wanted to extract was the following:

- Manufacturer
- Model
- Dimensions
- Load/Speed Index
- DoT number
- Special marks (e.g. Ⓐ - circled A representing Audi original part)

To illustrate, take a look at the tire. If you are not in the tire business, this might be a new and interesting learning for you. At least it was for us. For example, see the date code? Tires have their DOB as well, and even unused, some mechanical changes happen to it as it gets "older". For Frank, it means that a tire that is two years old, cannot be sold anymore.

Modus Operandi

I

Step 2. IDENTIFICATION OF SUITABLE TECHNOLOGIES

Identifying car tire was a challenge that might have seemed to be an easy one using the standard OCR (optical character recognition) approach. However, there are some other points to consider as well when choosing a technology path. With OCR, things to consider are as follows:

- There is no contrast between the symbols on the tire and the tire itself
- Some of the symbols are highly stylized and cannot be read but must be classified or identified
- Fonts used by some of the manufacturers are proprietary and there is no text body to train on
- Symbols which uniquely identify, for example, tire model are spread throughout the tire surface
- Difference between 2 unique tires might be in one letter which is 5mm big
- The speed which is required for conveyor belts is above 1.5 m/s to satisfy daily volume
- Tires come in various sizes (in our cases between 12 and 22 inches)
- Tires have radial distortion on their symbols
- Due to high mass of the product (tire) and the industrial setting there are a lot of vibrations (e.g. heavy transport trucks and trains) going on which affect data acquisition process

Our clients also used RFID (radio frequency identification) before and problems that arose were:

Time consuming Initial application of RFID chips on tires
RFID chip increasing cost/tire ratio
Tires are exposed to various forces during transport and handling and chips end up not working by the time they are read
Speed of the conveyor belt dictates the distance between tires to prevent wrong readings from RFID (using RFID equipment which does not increase cost/tire by too much)
Other approaches required changes by manufacturers in the manufacturing process or middleman to invest serious money into tire labeling solution (color coding, QR embossing/printing etc.)

Things to consider - Steps to take

CHOOSING THE RIGHT HARDWARE

The most important part (as with all AI/computer vision projects) is to make sure that data that is being analyzed is good data. Choosing the right camera for the job is essential. Making sure that industrial camera can handle all the concerns stated above in the article:

- Depth of field must accommodate various tire sizes
- Aperture/shutter speed/ISO settings can be set to match the conveyor belt speed and eliminate motion blur without incurring noise
- Hardware can be procured quickly and in sufficient amounts
- It has a nice API around which a solution can be built
- Build a nice Black Box which eliminates unpredictable lightning conditions, vibrations and floating particles while providing housing for camera and artificial lights and provides hardware interface to camera itself
- With the specified parameters it is imperative to use many sources of high-frequency lighting to provide enough stable light during short camera exposure time

Things to consider - Steps to take

I

SCOUTING THE LOCATION

Implementation location might have some real-world problems which require you to include them in the problem-solving equation.

A few examples:

- Initial tire offloading might be done at a place which is not covered by the security making it harder to leave the expensive equipment overnight. Therefore, the Black Box should be portable or easy to assemble. To prevent further errors there should be a calibration procedure to setup the camera and lighting after each move/assembly
- Networking infrastructure might be nonexistent or in bad shape
- The site might be remote making it hard to perform onsite maintenance therefore the solution should be as robust as possible
- The volume of the tires moved through the plant might not justify high-end hardware costs. Therefore, some thought should be given about algorithmic improvements to further reduce need for super expensive cameras

Things to consider - Steps to take

I

MEETING THE PERSONNEL

As is the case with many automatization tools, manual laborers might perceive implementation of the new system as a threat to their jobs. It is of vital importance to have full support of the upper management and key workers to be able to run the training process with confidence that it will be followed through diligently.

Workers might not be too enthusiastic about following instructions during data collection phase since it burdens them with additional tasks and no perceived benefits. Communication during the project is the extremely important since data acquisition might be an arduous process and prone to human error.

Solution for tire storing and distribution that uses modern technology of machine learning was a specific project we were working on. The extraction of the data from the tire requires the identification of suitable technologies, not just standard optical character recognition. To be able to describe the computer vision solution we developed, the taken approach can be divided into three main steps.

Taken approach

PoC - CHOOSE THE SCOPE

Building trust with a client and demonstrating the solution is usually achieved through Pilot/PoC stage. Choosing a scope as a small percentage of total unique tire number which need to be identified is a good starting point. All the necessary components of the system will be present within the Pilot, but the data acquisition/annotation phase will be much shorter and RoI might be easily calculated after it.

Taken approach

MONITORING THE DATA ACQUISITION AND LABELING THE DATA

During the data acquisition phase ardent monitoring should be performed either to detect some algorithmic flaws, system setup flaws or careless behavior by the people putting the tires on the conveyor belt. Allowing the errors to continue will in all cases prolong the Pilot phase, which is not in anyone's interest, but most importantly it will erode the trust with the client. Make sure you have very high level of confidence in your software and procedures before pointing fingers at employees.

Labeling the data should be performed in parallel with the data acquisition phase and is supported by custom app developed to speed up the process as much as possible using suggestions from machine learning models.

Taken approach

THE PIPELINE

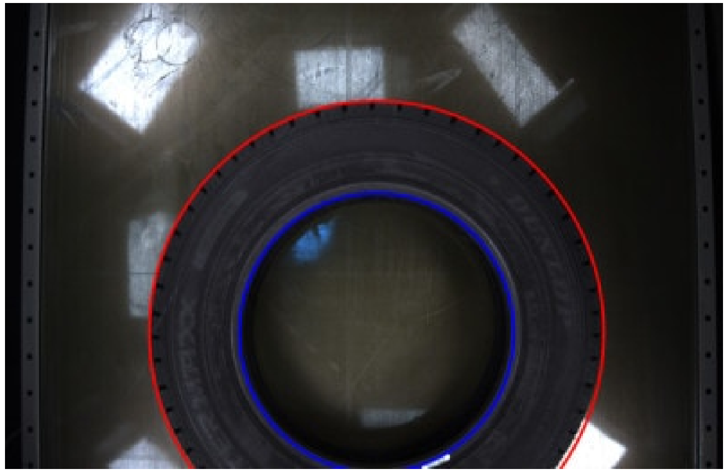
First we captured the images of a tire traveling on conveyer belt and detect inner and outer radius which will allow us to dewarp the tire (transform it into a trackline).

We have developed a specific algorithm to stitch different frames to get the whole tire picture. This reduces the costs needed for camera hardware by one order of magnitude.

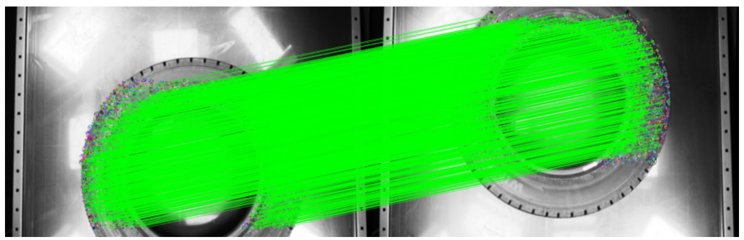
Based on the key points in both frames we can merge them to get the complete tire picture which we can push down the processing pipeline.

On such image text is located, and that text is used in a process of identification of tire. Using in-house built text classification and text reading (OCR) models we can identify trademark, model, dimension, load index, speed index and DOT written of tire sidewall.

And finally, the results are compared with the existing inventory catalogue for error correction and filling out the needed data.

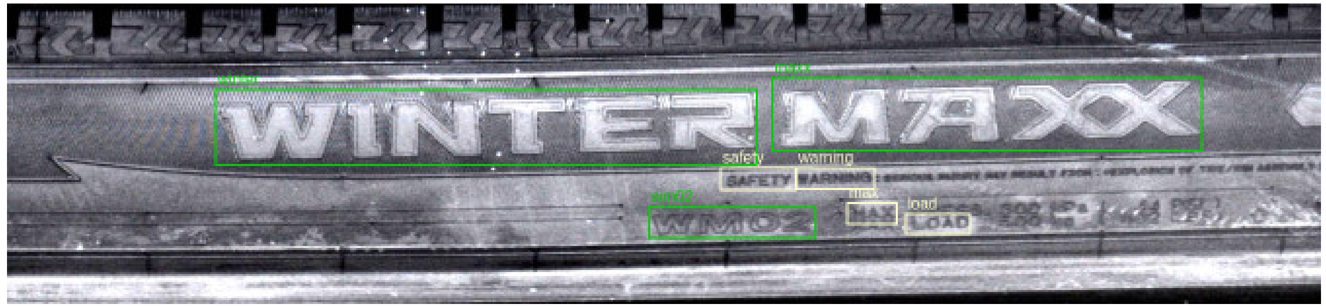


1. Tire on conveyor belt

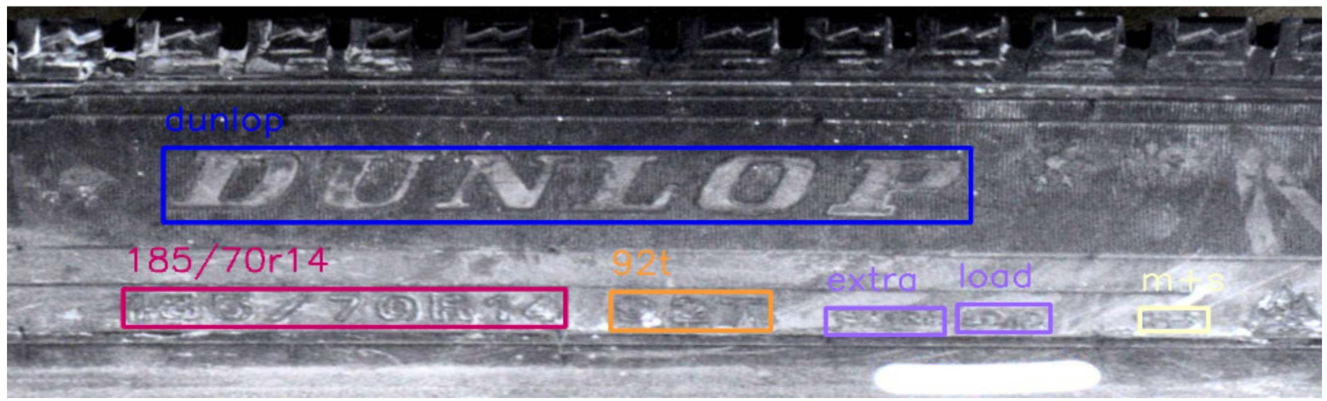


2. Keypoint matching

3. Dewarped Tire



4. Information extraction 1



5. Information extraction 2

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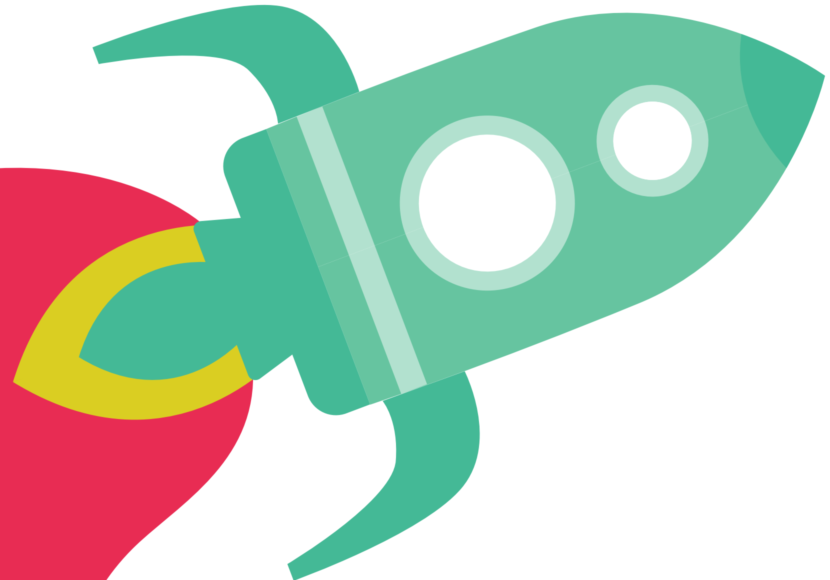
Result

It is important to present the client with clear numbers. We have matched human performance (you would be surprised by the skill level of people that are manually shuffling the tires around) in the upper 90% and allowed businesses to scale their operations. Implementing AI based solutions inside industrial environments is always a challenge. This time we successfully overcame what was thrown at us.

To conclude: Do not try this at home

Industrial AI applications always require a big upfront investment to cover the development costs and usually the resources required to do so are not available to hobbyists or individuals. And even more so, products in the industrial domain require a dedicated team of professionals focused on solving problems which pop up (inevitably) and were not predicted in planning sessions or when discussing implementation details.



Accelerating business transformation through innovative technology

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