Connecting the Dots: Matching Existing Solutions to New Production Defects

Problem

Defects occur frequently on the production line and quality engineers would have to address them on a daily basis. Valuable time are spent to fix these defects so similar defects are aggregated into the Knowledge-Base along with a common solution. However, this is a manual process that requires up to 24 hours per month of labor, and it is very prone to human error.

How can BMW Group increase efficiency in the Problem Management Process?

What's the most relevant solutions to a new defect?

Does the solution exist in the current Knowledge-Base?

Solution

A recommendation tool that suggest existing solutions to new defects

Problem Management Process

The PMP system is used to manage defects and is consisted of the following three steps:

1. Identify Defects
   - Production defects are reported plant-wise, along with a short remark describing the defect in German and/or English.

2. Analyze Incidents
   - Critical defects are further analyzed and elaborated into incident descriptions.

3. Solve Problems
   - Similar incidents are assigned a unique Problem Number along with a detailed problem solution.

Data and Methods

Each step contains a respective dataset and we conducted analytical methods both on and across the three datasets.

- **Rework**
  - Over 4.3 million defect entries across different plants since 2019
  - Structural features: defected vehicle parts and defect type
  - Unstructured features: multilingual and succinct rework remarks
  - Less than 0.05% entries are connected to a Problem Number

- **Incident**
  - Around 11 million incidents
  - Over 80% incidents are connected to a Problem Number
  - Contains more detailed multilingual description about the defect

- **Knowledge-Base**
  - -891 thousand solutions (Problem Numbers)
  - Detailed multilingual description of both defect and solution

Cosine Similarity

Problem Numbers are ranked based on cosine similarity of sentence embeddings of Rework remark and solution title to assess the relevancy between the defect and proposed solution.

Rouge Score

Rouge score measures overlap of n-gram between Rework remark and solution description.

Optional Features:
- Vehicle Model
- Type of Defect

Keyword Extraction

Challenge: Incident descriptions contain many irrelevant information.

Solution: Identify most important information by extracting keywords of each topic cluster.

- Yet Another Keyword Extractor (YAKE!) Collection-Independent Automatic Keyword Extractor
- Regular Expression of Option Codes and Severity Index
- Extracting Noun-Verb pair through part-of-speech (POS) tags

Objective: recommend all Problem Numbers in topic clusters that contain relevant keywords to the respective defect

Results and Impact

- The recommendation tool performs the best when it includes **both Defect Type** and **Vehicle Model** as additional inputs (accuracy: 74.13%, MRR: 69.23%)
- The defect solution recommendation tool relieves plant workers of cumbersome manual work and allows them to focus on roles that require more human expertise
- Machine learning also reduces human errors such as creating the same solution twice if they are unable to find the right solution among thousands of entries
- Improves efficiency by 90% while allowing flexibility in inputs to accommodate for user's domain knowledge

**Large-Scale Validation Result**

- **Accuracy**
  - Mean Absolute Error (MAE)
  - Mean Squared Error (MSE)
  - Mean Absolute Percentage Error (MAPE)

**8K** projected defects matched per day

**20min** work time reduced per operation

**€ 500K** annual labor expense used more efficiently

**9K+** manual labor hour optimized annually

**30+** quality engineers directly assisted