

AI-Challenge „Industry“

The SmartFactoryOWL is a research and development platform for the factory of the future with a production area of approx. 2000 m², which is shown in Figure 1. Its purpose is to develop and test new Industry 4.0 technologies and to bring them into industrial application with the support of an interdisciplinary team of experts.



Figure 1: Production area of the SmartFactoryOWL

The SmartFactoryOWL consists of different modules. In the AI Challenge, methods of artificial intelligence for anomaly detection are to be developed for two of these modules - a conveyor system and a reconfigurable production system.

In the conveyor system shown in Figure 2, objects can be transported with five conveyor belts on two different levels.

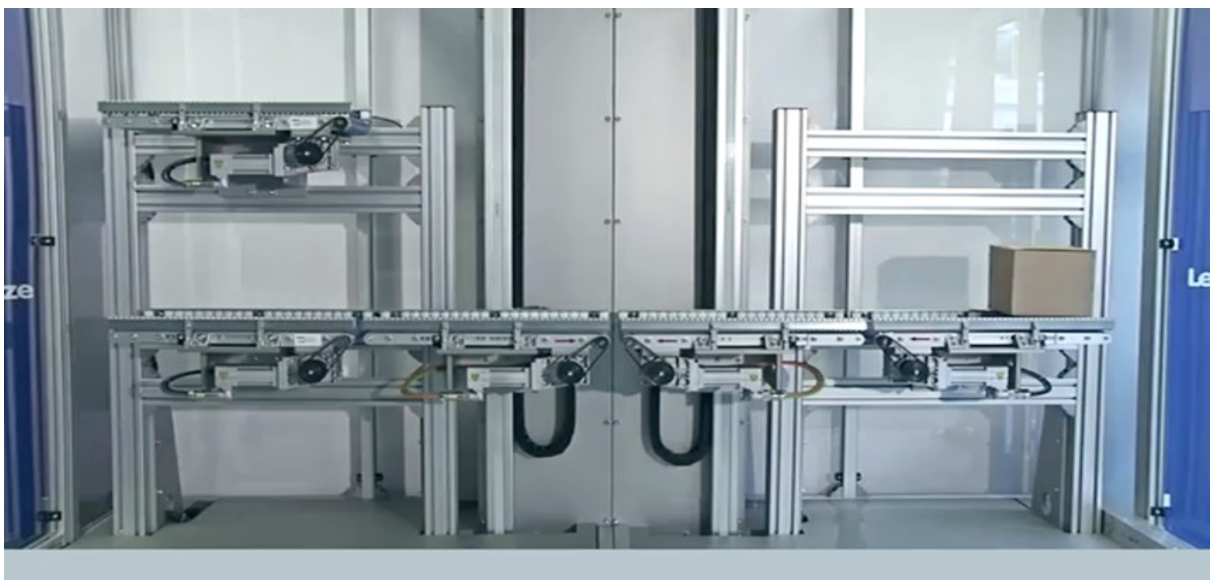


Figure 2: Conveying system in the SmartFactoryOWL

Five drives are used for the horizontal movement of the conveyor belts, with two further drives the middle the conveyor belts can be moved in vertical direction. An energy meter makes it possible to measure the power consumption of the entire conveyor system. In addition, sensor data from the programmable logic controller of the conveyor system are

recorded. This provides the positions of the transported objects as well as electrical measurement variables (voltages, currents and power consumption of individual conveyor belts). Typical anomalies that occur during the operation of the conveyor system are unusually high power consumption, stopped conveyor belts or sensor errors that lead to modified signal values.

The reconfigurable production system allows for the storage, transport and processing of raw materials. It consists of seven sub-modules, which are shown in Figure 3.

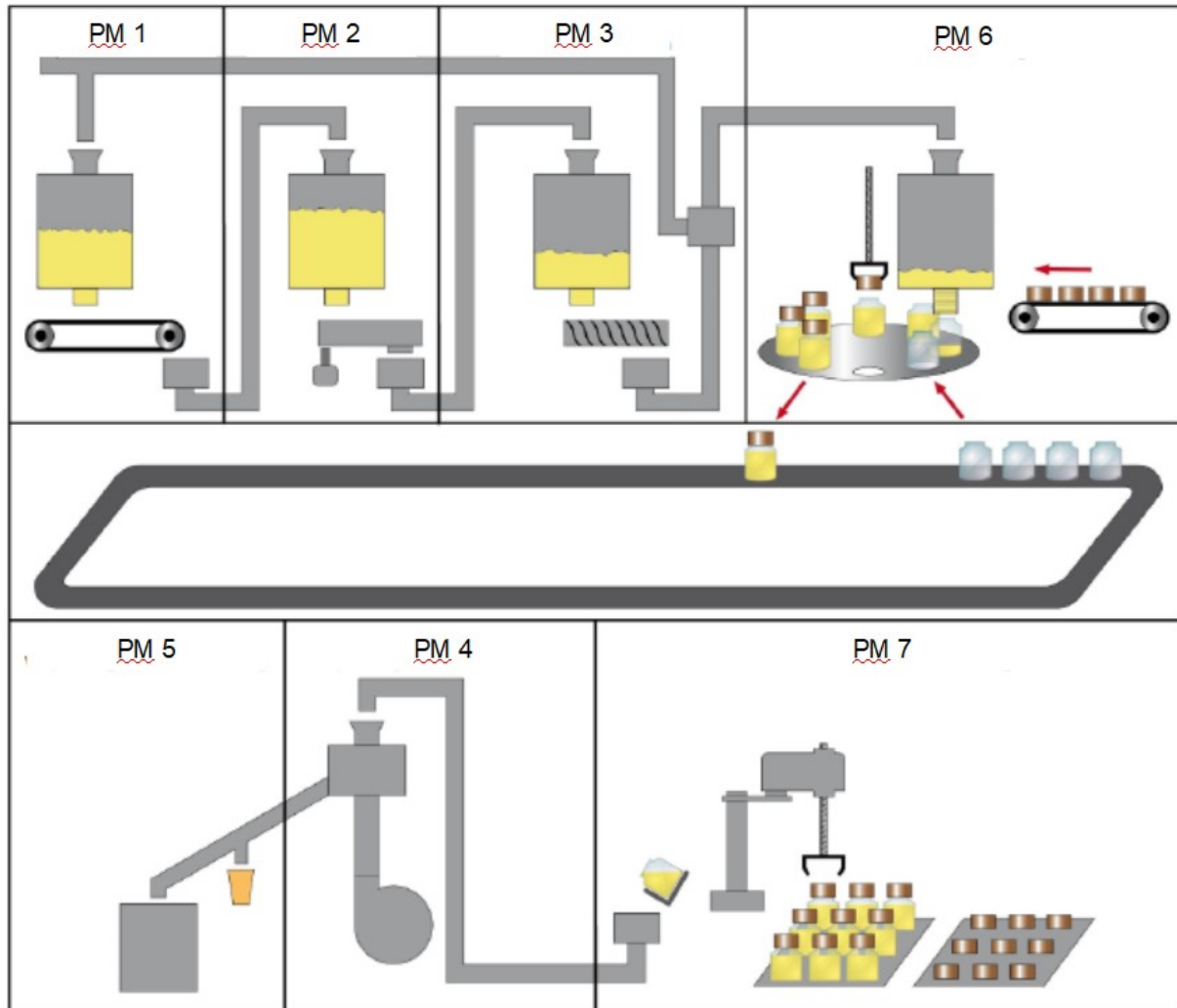


Figure 3: Sub-modules of the reconfigurable production system

The overall process is made up of the parallel processes "bottle filling with storage" and "packaging material production". The process "bottle filling with storage" comprises the delivery in submodule PM 1, a bulk storage in submodule PM 2, weighing and dosing in submodule PM 3, and filling the bulk material into bottles in submodule PM 6. In the process "packaging material production", bottles are transported from the storage area to a bottle opening device with the help of a pick and place robot. The removed bulk material is then blown into the air in process module PM 4 and heated. The packaging material produced in this way is filled in process module PM 5. Numerous process data are recorded in the reconfigurable production system, which are described in the file "DescriptionProduction.pdf".

Typical error cases in the reconfigurable production plant are, for example, conveyor belt standstills, empty containers in submodules PM 1 – PM 3, blockages of the turntable or errors when gripping the lid in submodule PM 6.

Deviations from the normal behaviour in the modules of the SmartFactoryOWL indicate errors which, if not corrected in time, can lead to repair costs or expensive production downtimes. It is therefore important to detect such anomalies at an early stage and to eliminate the causes immediately. For this purpose, the task of the AI Challenge will be to implement anomaly detection methods for the conveyor system and the reconfigurable production system.

As a starting point for the development of anomaly detection, sensor data from the two modules are available, each of which was acquired during several process cycles. In the conveyor system, a process cycle consists of a transport process from the bottom right position to the top left position and back again. In the reconfigurable production system, raw material (corn) is transported from PM1 via PM2 to PM3. Here it is weighed and the portions are filled in PM6 into bottles and stored in a tray in PM7. On demand a production is done in PM 4 (emptying bottle and produce popcorn in a heater) and PM5 (packing in cup or pot). Most of the process cycles were recorded during error-free operation of the conveyor system and the reconfigurable production system. In addition, the data of some further process cycles are provided, which contain the typical error cases described above for the two modules.

The evaluation of the anomaly detection shall be carried out separately for the two modules "conveyor system" and "reconfigurable production system" on evaluation data sets, each containing the sensor data from one process cycle. Half of the process cycles in the evaluation data sets are faulty, while the other half were recorded during fault-free operation of the respective production module.

The task of the challenge is to classify the evaluation data records either as error-free or as faulty. The results are to be entered in the two files "DetectedAnomaliesConveyor.csv" or "DetectedAnomaliesProduction.csv", whereby for each data set that was detected as faulty, the value "True" is to be entered in the column "anomaly" and the value "False" for each faultless data set. The F_1 score is used as a metric for evaluating the results:

$$F_1 = 2 \cdot \frac{\text{sensitivity} \cdot \text{precision}}{\text{sensitivity} + \text{precision}}$$

with

$$\text{sensitivity} = \frac{TP}{TP + FN}, \quad \text{precision} = \frac{TP}{TP + FP}$$

and true positives TP , true negatives TN , false positives FP , false negatives FN .

The following files are available for processing the task:

1. For the module "conveyor system":

- „TrainingDataConveyor.csv“: Sensor data from 45 process cycles, which were recorded during the error-free operation of the production plant.
- „ValidationDataCoveyor.csv“: Sensor data from 10 process cycles with typical error cases.
- „EvaluationDataConveyor“: Sensor data from 50 process cycles, half of which is faulty, while the other half was recorded during error-free operation of the conveyor system.
- „DetectedAnomaliesConveyor.csv“: The results of the anomaly detection for the application scenario "conveyor system" are to be entered in this file.

2. For the module "reconfigurable production system":

- „DescriptionProduction.pdf“: More detailed description of the reconfigurable production system and the sensor data recorded there.
- „TrainingDataProduction“: Sensor data from 22 process cycles, which were recorded during the error-free operation of the production system.
- „ValidationDataProduction“: Sensor data from five process cycles with typical error cases.
- „EvaluationDataProduction“: Sensor data from 24 process cycles, half of which is faulty, while the other half was recorded during error-free operation of the reconfigurable production system.
- „DetectedAnomaliesProduction.csv“: In this file the results of the anomaly detection for the application scenario "reconfigurable production system" are to be entered.