Tech Experience

Pivot Park Screening Centre

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Seeking to leverage
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TABLE OF CONTENTS

Challenge 1

Can we detect automatically that a suspicious pattern occurs?

Problem

- Human supervision is not efficient and effective for the maintenance of a 24/7 operation.
- Unidentified errors in process may result in significant damage without human supervision.
- Pattern recognition is not possible when during the unattended hours of operation.
- Any failure in test procedure directly impacts revenue and time spent on overall process.

Solution 1: Pattern Detection After Test

- Machine learning can solve pattern recognition tasks with supervised learning.
- A dataset can be prepared from test results. If a suspicious pattern is detected by expert, the test result should labeled with possible error:

TestID	Timestamp	Parameter1	Parameter2	...	Label
111	2012-12-15 11:15:09.205	3.632	1023		Successful
112	2012-12-14 11:15:09.205	2.786	987	...	Inaccurate Dispensing
. .	. .	. .	. .	...	. .
113	2012-12-13 11:15:09.205	4.145	987		Loss of Reagent Stability

- After dataset prepared with both succesful results and anomalous results with enough variety, a machine learning model can be trained to classify test results and used for future tests.

Value Proposition

- Unattended hours of operation can be controlled by machine learning model.
- If machine learning model identifies an anomaly from test results after process, any action can be taken accordingly. i.e. restart testing procedure if there exists an anomaly in centrifuge process
- Machine learning model can outperform expert analysis which minimizes human error. [1]

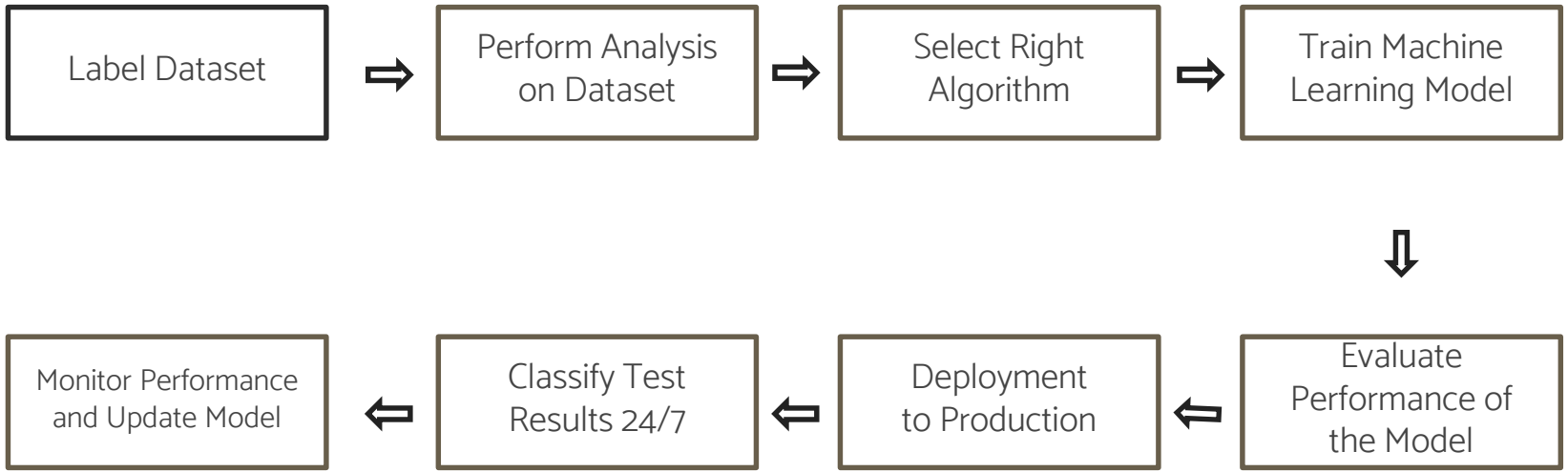
Dataset Preparation

- Machine learning models' performance significantly depends on dataset quality when using supervised learning algorithms.

- Prepared dataset must be labeled correctly and each label must have enough samples to represent distribution of the anomaly so, large datasets may needed.

- The dataset preparation step is labor-intensive but machine learning models make overall automated testing task more efficient and effective.

Machine Learning Procedure



Model Evaluation

- If dataset includes small percentage of a label, i.e. %0.5 of test results that are labeled as inaccurate dispensing in dataset, evaluation metric of machine learning model must be chosen properly due to imbalanced label representation.
- Since each instance in dataset represent anomaly/non-anomaly label and actions are taken according to label, chosen metric is crucial for using trained machine learning model in production.
- In model evaluation step, several evaluation metrics can be used:
  - F1 score
  - Precision
  - Recall
  - ROC Curve
- After evaluation with these metrics, we can use the trained model to classify every test, if trained model satisfies our constraints.

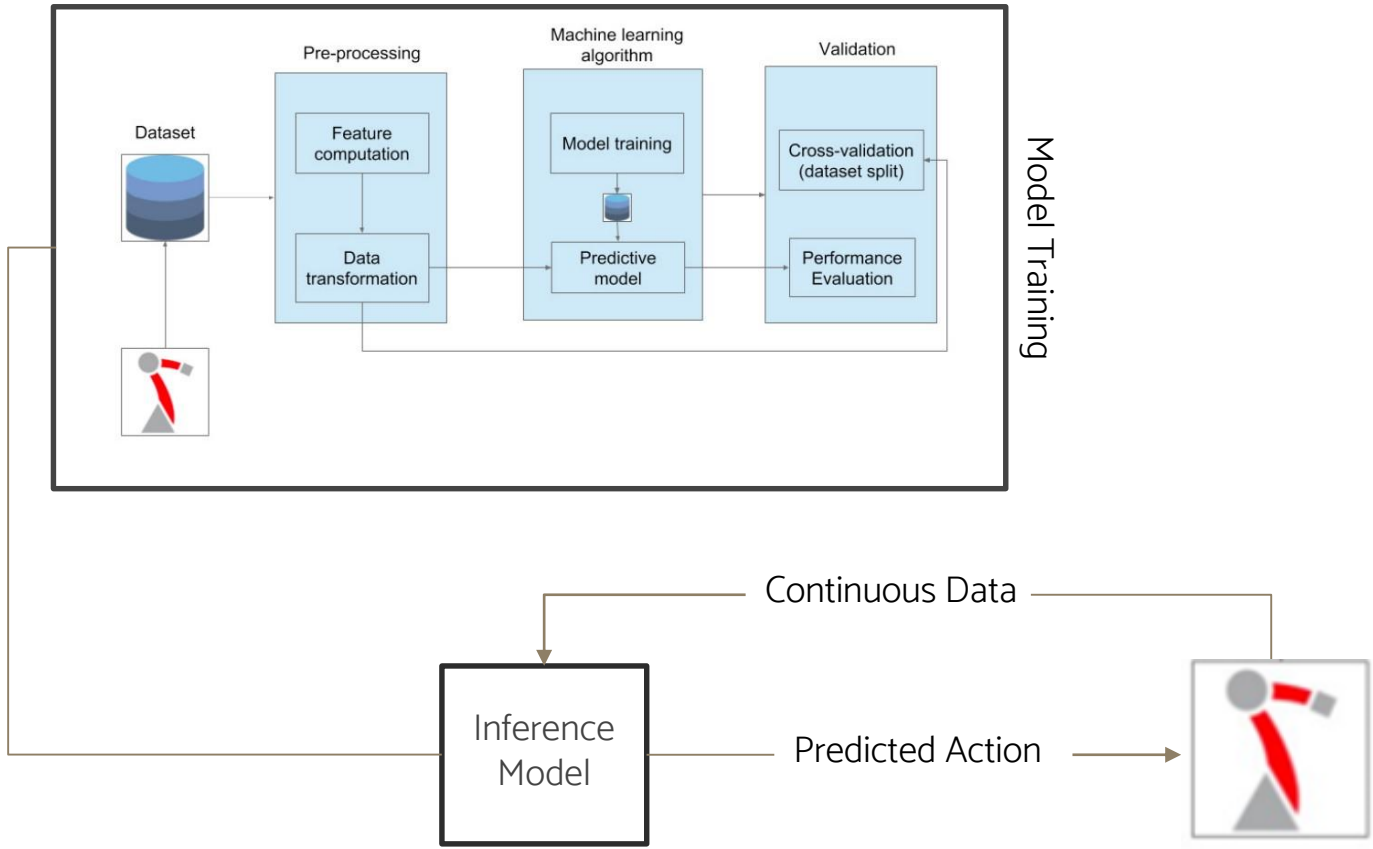
Solution 2: Pattern Detection During Test

- For real-time detection of unwanted patterns during testing, we need continuous data-streams from the instrument.

- After labeling each data-stream with correct anomaly or non-anomaly and training a model in a similiar way as in slide 9, trained machine learning model (inference model) can identify patterns during the test process and take action according to its prediction. i.e. if there's a problem in centrifuge process, restart centrifuge process and continue testing

- For a real-time machine learning application, latency is important factor which affect the success of the action that is determined by machine learning model. Inference model can be used on a cloud server or on edge.

Real-time Machine Learning Procedure



Model in Production: Cloud or Edge?

- If machine learning model deployed on cloud server, latency, network failure or low bandwidth affect real-time detection.

- Machine learning models that work on edge -local computation units- are faster and efficient for real-time anomaly detection to take action on each scenario but may face with power, memory and computational constraints with respect to complexity of machine learning model.

- According to a research [2], in most industries, on edge computation is more efficient and effective than relying on cloud computation.

Challenge 2

Can we analyze the physical situation?

Problem

- Human supervision is not efficient and effective for the maintenance of a 24/7 operation.
- Machine failures are time-consuming and expensive process if there is not any established predictive maintance system.
- Maintanence of robotic process is not possible when during the unattended hours of operation.
- Any failure in machines directly impacts revenue and time spent on overall test process.

Solution 1: Machine Learning

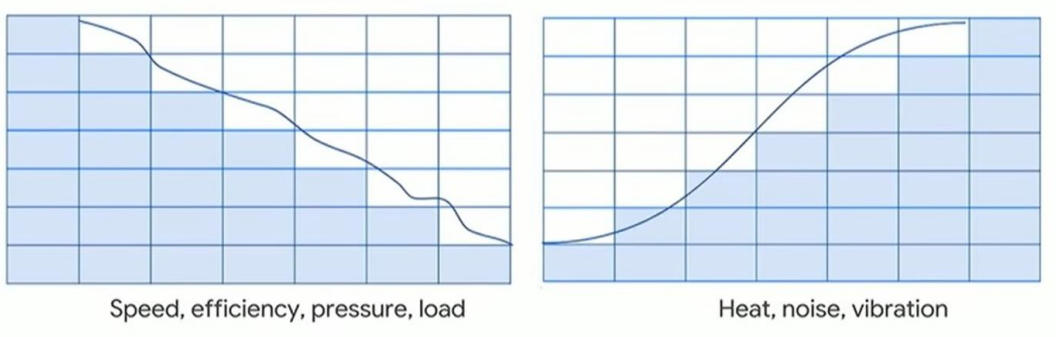
- Machine learning can solve maintenance problem with supervised learning.
- A dataset should be prepared from tracking data points such as sensor data from robots or current testing step. If a failure happens, all data points and state of the machine should be labeled as failure and vice versa:

MachineID	Timestamp	Heat	Speed	...	Label
1	2012-12-15 11:15:09.205	28.25	102		No failure
1	2012-12-15 11:16:09.205	28.26	102.1	...	Failure due to X
. .	. .	. .	. .	...	. .
8	2012-12-16 11:15:09.205	46.2	89.2		No failure

- After dataset is prepared, machine learning models can be trained to achieve 24/7 predictive maintenance task which proactively determined before any failure happens.

Solution 1: Machine Learning

- Machine learning algorithms can learn patterns of machine failure by using prepared dataset.



Source: [3]

Solution 1: Machine Learning

- For predictive maintenance, we need to establish a hypothesis such as manipulation of the dataset to look overall objective as predicting failure in 2 weeks. After dataset manipulated in this manner, we can predict a failure in instruments before it happens and can take action.

MachineID	Heat	Speed	...	Label
1	28.25	102		No failure in 2 weeks
2	28.26	102.1	...	No failure in 2 weeks
. .	. .	. .	...	. .
8	46.2	89.2		Failure in 2 weeks

Solution 2: Image Recognition

- Machine learning algorithms including deep convolutional neural networks can recognize an instrument failure from images if there exist any visual representation of failure from by using video surveillance.

- If it's possible to detect an instrument failure from images that are gathered from video surveillance, multiple cameras can be assigned to each robotic arm for data preparation.

- Multiple image sources can provide physical situation of each instrument in every angle.

Solution 2: Image Recognition

- After collecting enough data for deep learning algorithms, the dataset needs labeling for each situation such as:

MachineID	Label
Arm1_Image1	No Failure
Arm1_Image2	Motor Failure
. .	. .
Arm8_Image6	Power Failure

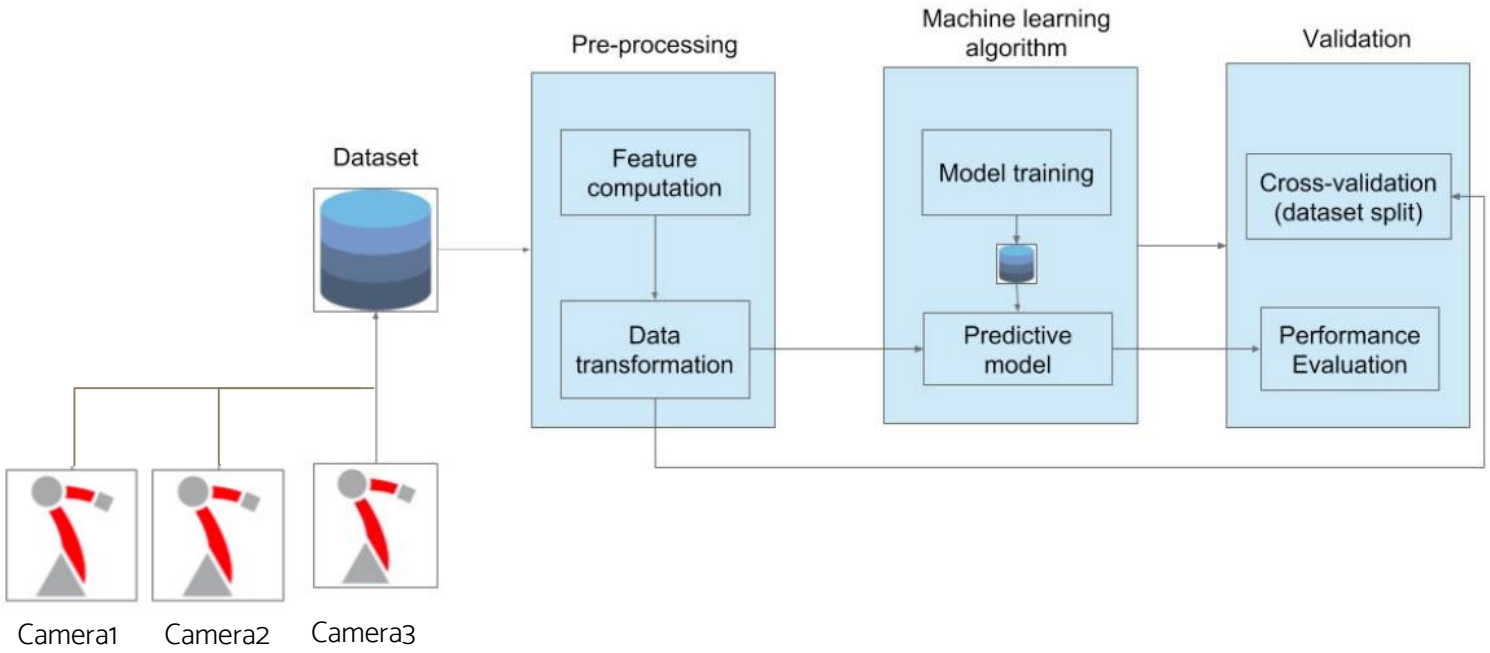
Arm1

Arm2

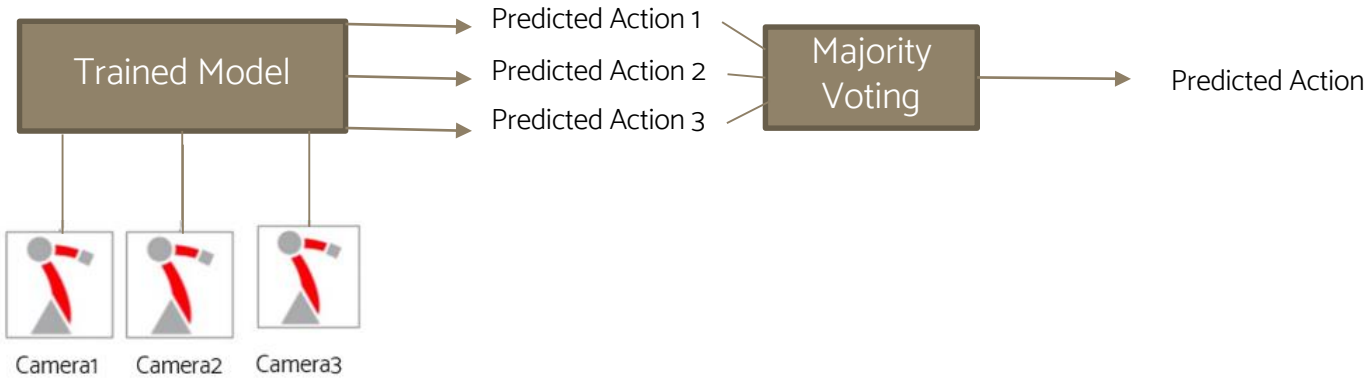
Arm8

- After labeling, same procedure in slide 9 should be applied to detect any failure from physical situation of the instrument.

Training : Image Recognition Model

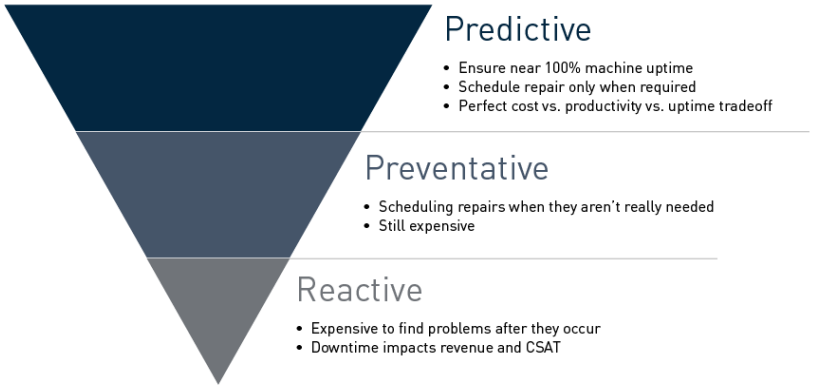


Inference : Image Recognition Model



Value Proposition

- Predictive maintenance of instrument failures are efficient and effective in comparison to reactive maintenance



Source: [4]

PREDICTIVE MAINTENANCE

Reduce Downtime

Using predictive maintenance reduces downtimes in 24/7 operation

Schedule Repair

If the model classifies a machine as «needs repair» with respect to established hypothesis, proactive actions can be taken.

24/7 Successful Operation

Since overall objective is less human intervention and successful operation at day and night, predictive maintenance is an efficient method.

Less Human Supervision

Unnecessary replacement or repair of any instrument can be reduced and less action will be taken by using data-driven predictive maintenance.

Challenge 3

Can AI be used to improve quality and efficiency of the robot system?

AI & Robotics

- AI is a general term that implies the use of models to replicate intelligent human behavior. In scope of pivot park's case, we can use specialized AI as a starting point.
- Specialized AI in this case is a term for a robot that perform only special tasks, such as the centrifuge process, seal removal or transfering compound to test plate.
- Since these steps are already automated, we can use specialized AI for each step that needs human supervision in this process which can be replicated by a machine learning model.
- In a 24/7 working operation, we can maximize operational efficieny by proactively taking action with predictive maintenance and utilizing testing procedure with more reliability with suspicious pattern recognition.

AI & Robotics

- Machine learning models can learn patterns as well as visual representations from data. If AI & robotics are integrated, robots can sense and learn which mimics human behaviour.
- These models can be used for finding damaged test samples, identification of errors in testing procedure from samples and prediction of machine failure in near future.
- For establishment of these systems, the procedure needs data-driven robotics approaches, which makes data gathering operation more crucial while building AI-assisted automated system.
- Since machine learning is heavily depend on dataset quality, data preparation step needs labor-intensive labeling process.

Conclusion

Overall review of proposed methods

Conclusion

- In this presentation, several methods are proposed with respect to given challenges.
- Predictive maintenance is widely used around different industries to prevent machine downtime
- Since machine learning heavily depends on dataset quality, this labor-intensive task needs investment on dataset preparation and data pipelines for real-time predictive maintenance with machine learning.
- Future improvements can be established over these proposed methods with better domain knowledge on high throughput screening and development of medicine.

THANKS

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REFERENCES

1. https://www.bbc.com/news/health-50857759
2. https://www.iotworldtoday.com/2020/01/30/edge-computing-benefits-for-ai-crystallizing/
3. https://www.youtube.com/watch?v=4wneZDEB3VA
4. https://mapr.com/solutions/ai-analytics/predictive-maintenance/