Artificial Lift R&D Council

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The Status and Workflow of Artificial Intelligence for Artificial Lift

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Brightics AI ACCELERATOR

Artificial Intelligence Workflow

The full AI workflow consists of these five steps with additional steps of communication on either side of it.

COMMUNICATION

CHANGE MANAGEMENT

Data Acquisition	Data Labeling	Feature Generation	Model Selection & Tuning	Training & Inference
• Right kinds of data are identified • Raw data are obtained • Outliers and bad data are removed • Missing data are filled in • Uncertainties are quantified	• Domain knowledge is added • Non-measurement data are filled in • Could be categorizations, annotations, or others	• Right features are selected • Synthetic features created in accordance with domain knowledge, or by trial-and-error	• Best model kind and topology is selected • Hyper-Parameters of training algorithm are tuned • Both are trial-and-error processes	• Model training takes place • Reporting on model performance and cross-validation • Model can be used for inference

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80% of frustration

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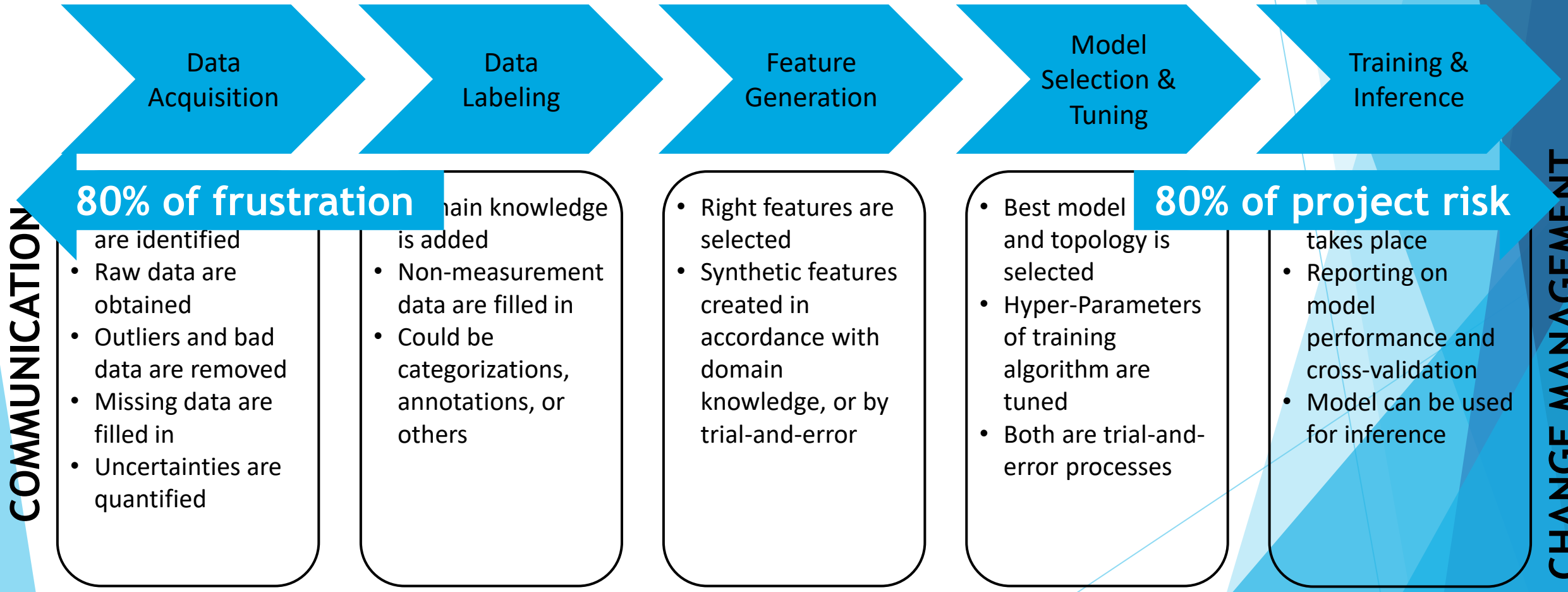

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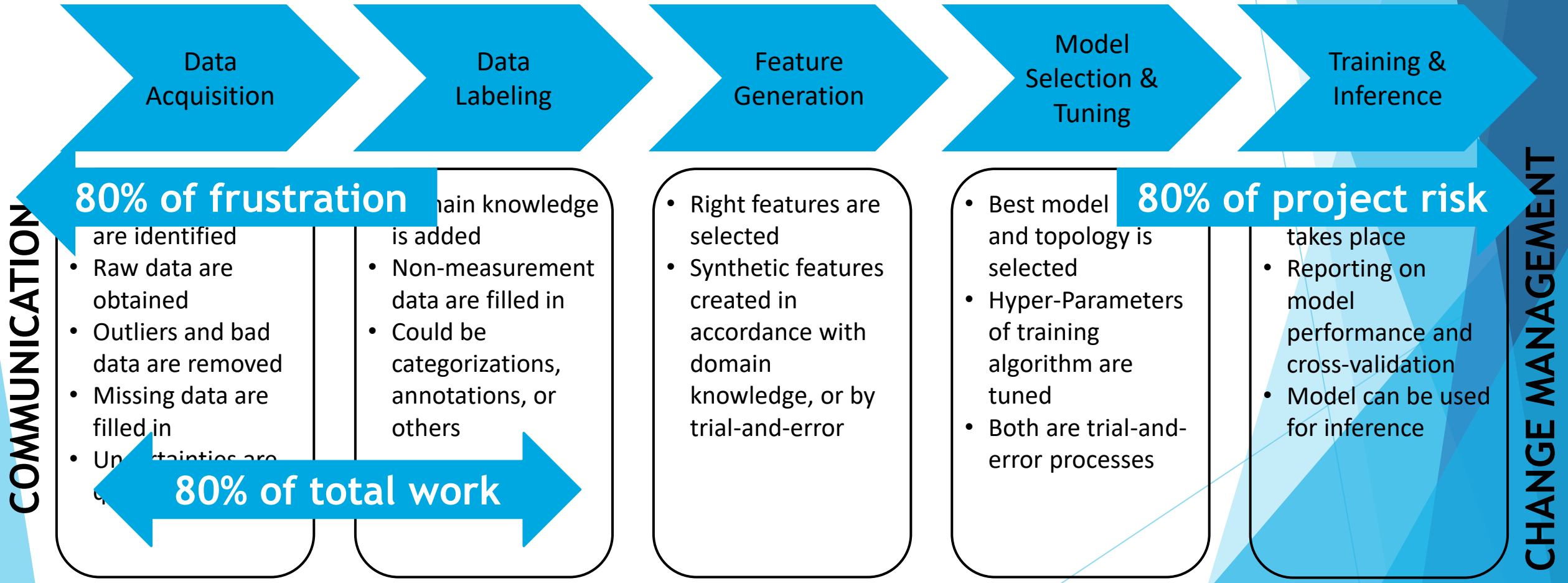

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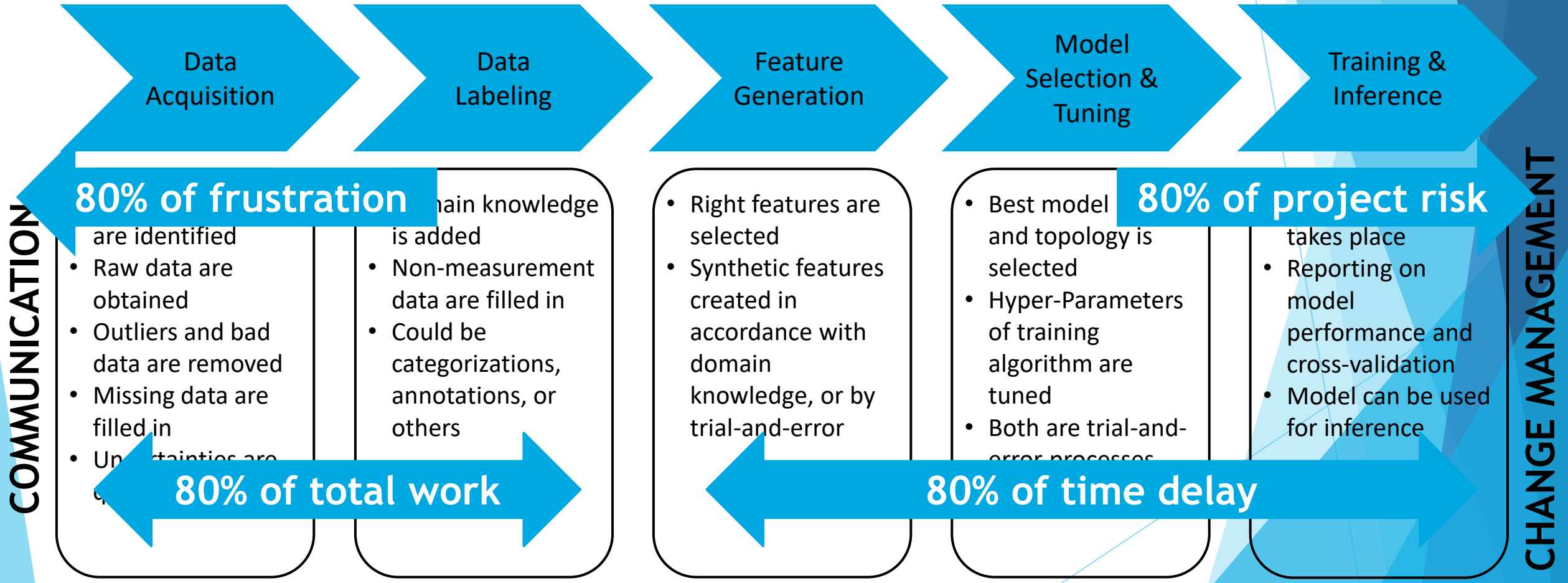
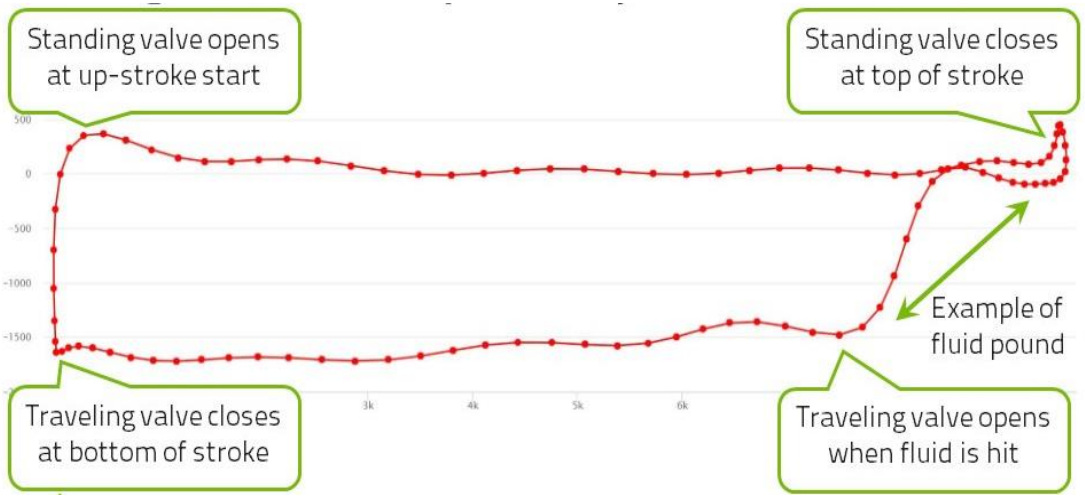


Active Learning

Key Ideas: The process of manually labeling data can be largely automated by labeling in an interactive manner that leads to labeling data points in the right order – and reduces labeling effort by 90%.

Examples of Data Labeling

Data labeling can take many forms – some of them are isolating different areas in an image.



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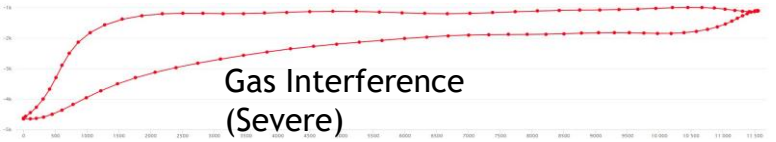
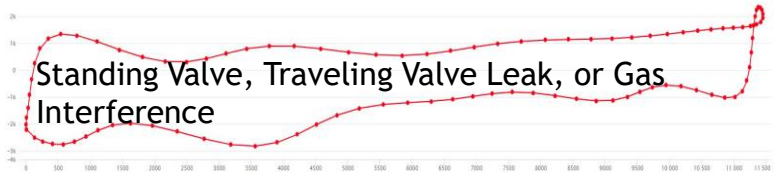
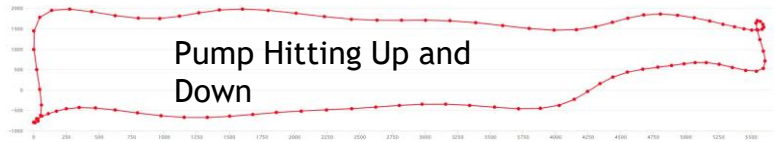
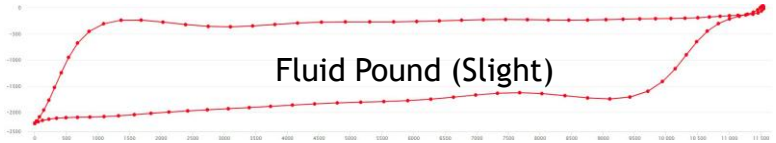
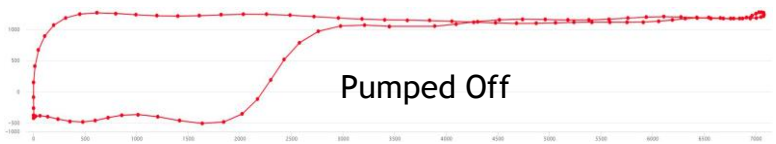
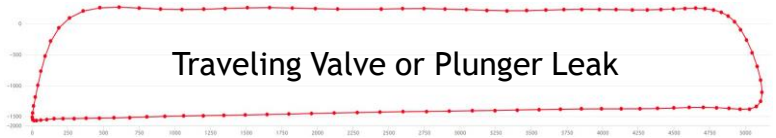


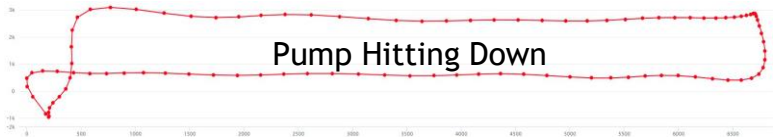


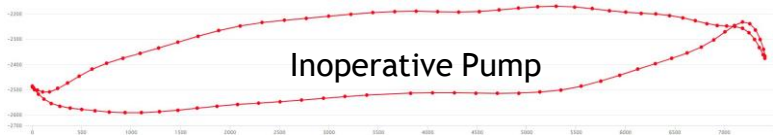


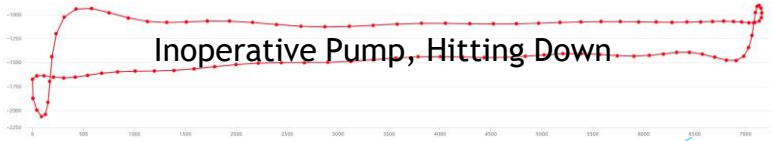










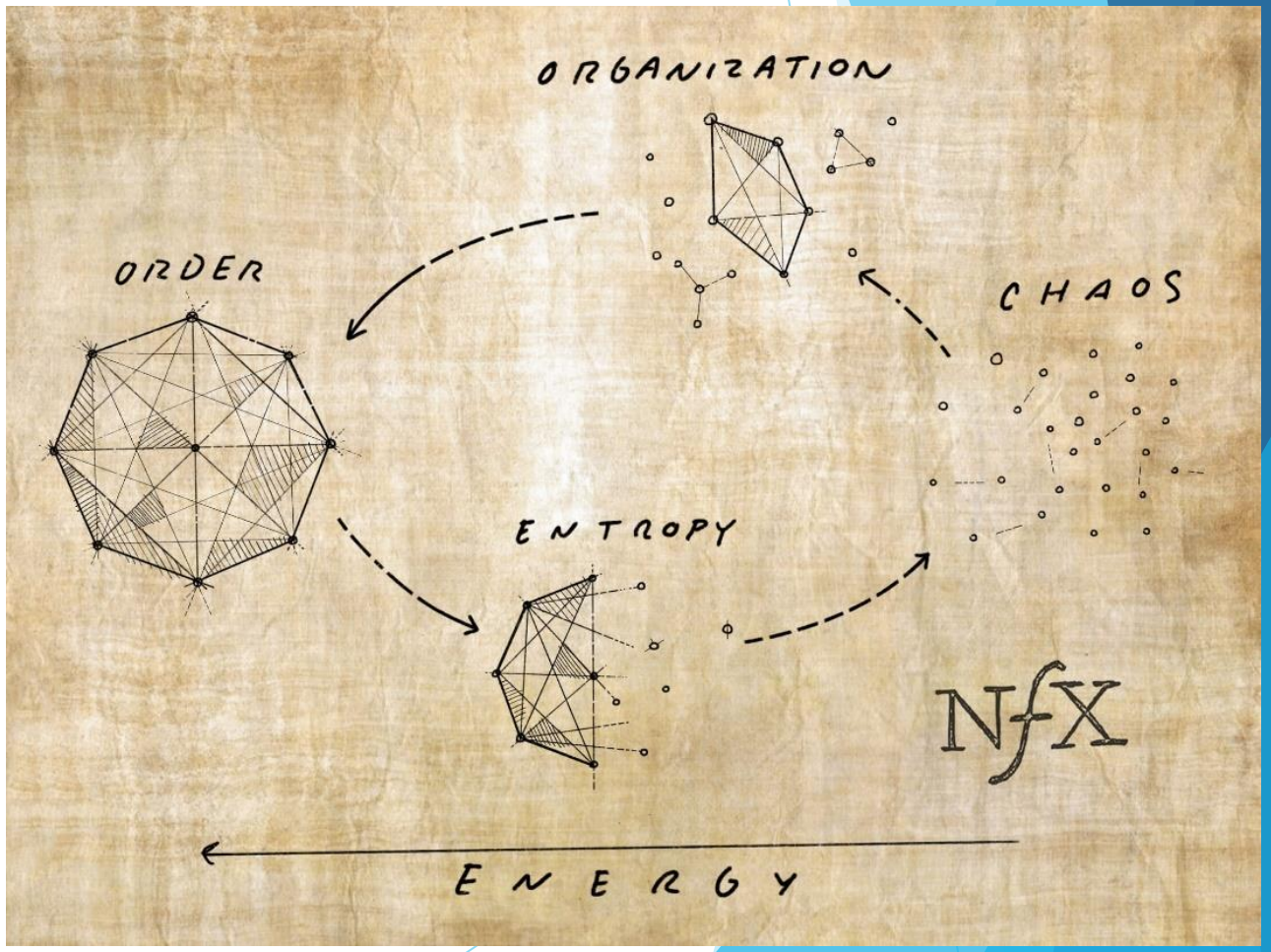


Labeling is Effortful

Humans must label each data point in the training dataset – and generally do so in arbitrary order. But order matters!

Information Gain

- As each data point is labeled, we gain information
- However, some data points are worth more than others
- Let's sort them and label the good ones first
- Law of diminishing returns
  - At some point, the additional information gain is so small, that we can stop labeling before getting to the end of the training dataset

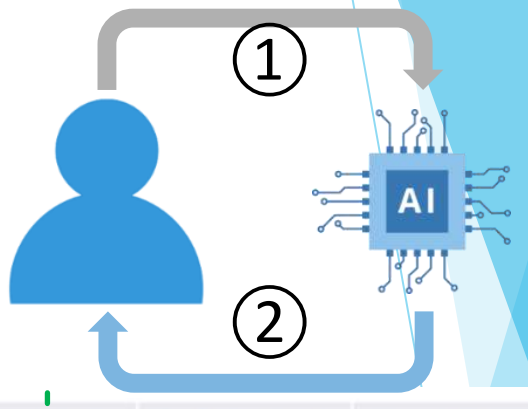


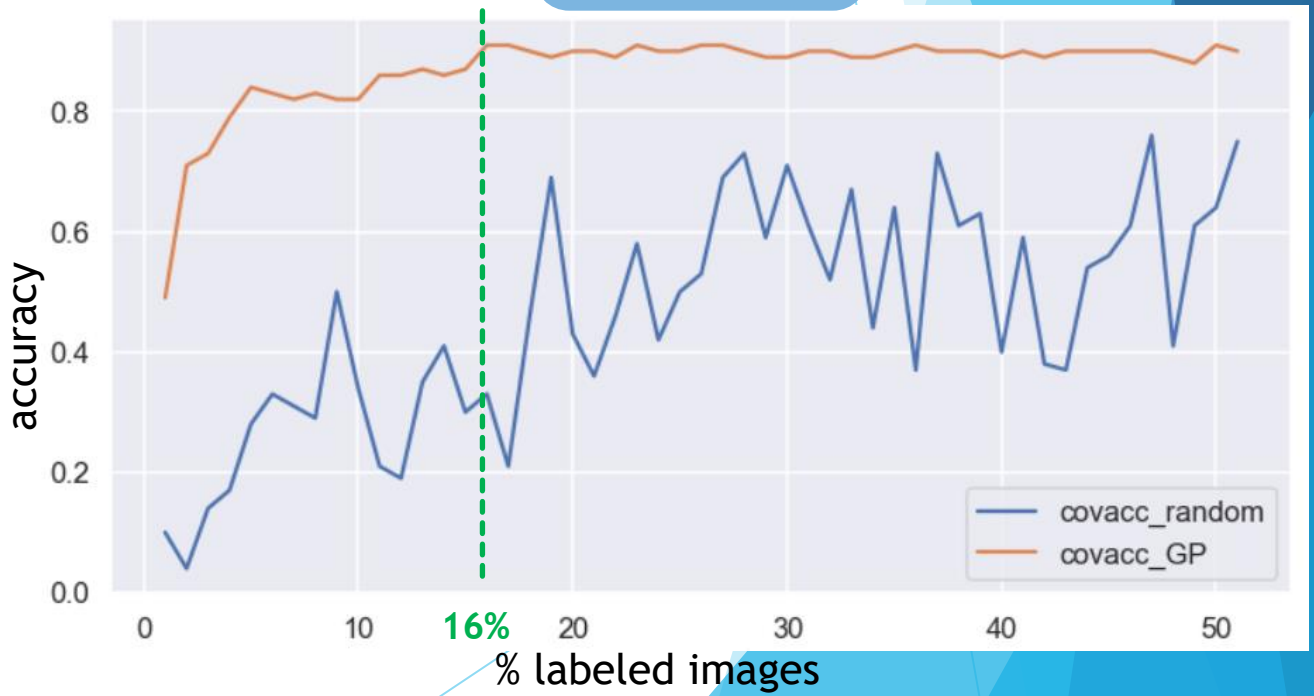
Active Learning – Order Matters!

Data points are sorted by going through a loop of a little labeling, training, and evaluating the confusion of the model.

Labeling Loop

- We begin by manually labeling some data
- A simple model is trained and executed on the full dataset
- We sort the unlabeled data points by the amount of uncertainty that the model outputs for them – most uncertain at the top
- Lather, rinse, repeat
- Stop once the uncertainty falls below threshold
- Manually check the automatically labeled data
- Only about 10% of all data needs to be labeled, the rest can be auto-labeled
- Example: 16% labeled data leads to maximum model accuracy – no improvement thereafter





2

Feature Generation

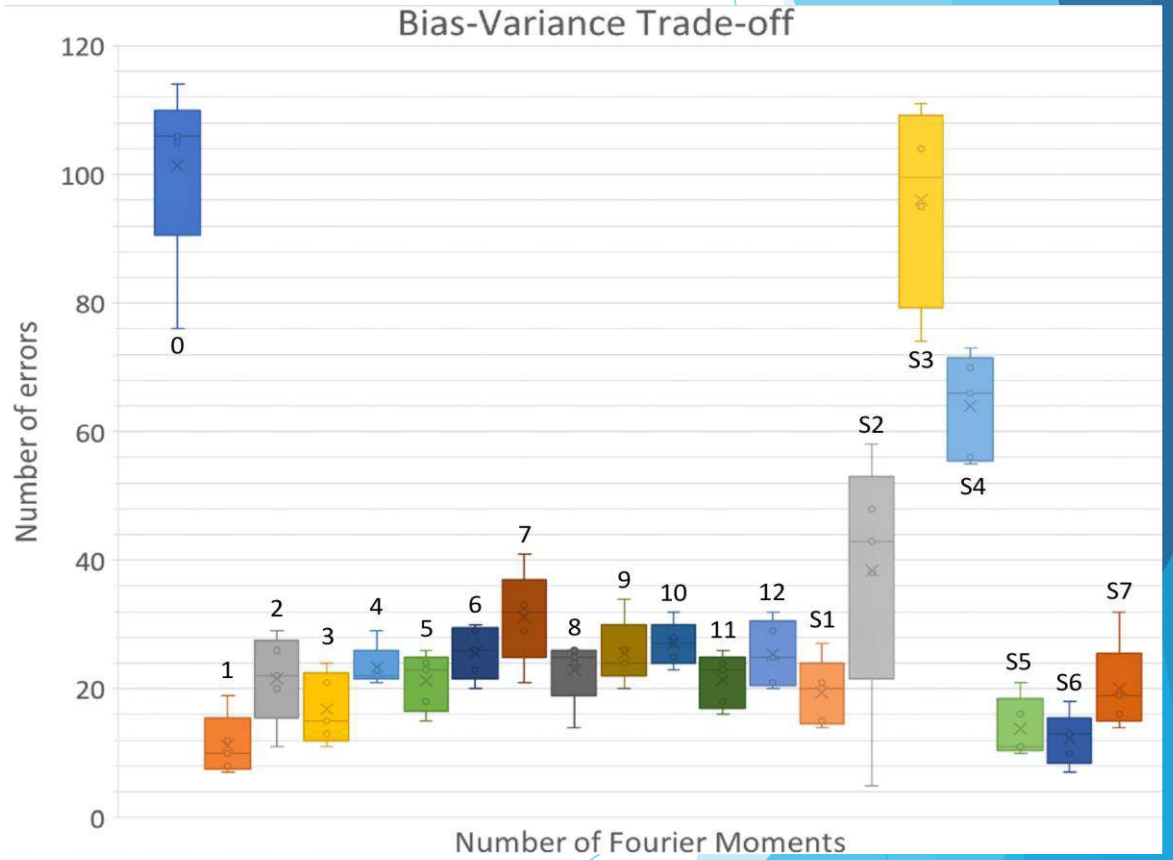
Key Ideas: The right features must be selected, or new synthetic features generated in order to represent the situation in the best way. Apart from adding human domain knowledge, this can be done automatically as well.

Feature Selection & Engineering

Of the available features, we select the right ones or create new ones to enable the maximum model quality – in view of the bias-variance trade-off.

Feature Set Comparison

- **Normal Way**
  - Domain experts add new synthetic features
  - For every feature set, we run several models to gauge bias and variance
  - Select the best
  - Manual process and time-consuming
- **New Way**
  - Many automatic synthetic features are generated and tried out in an automated process
  - The best feature set is selected and output
  - Depends on fast training run



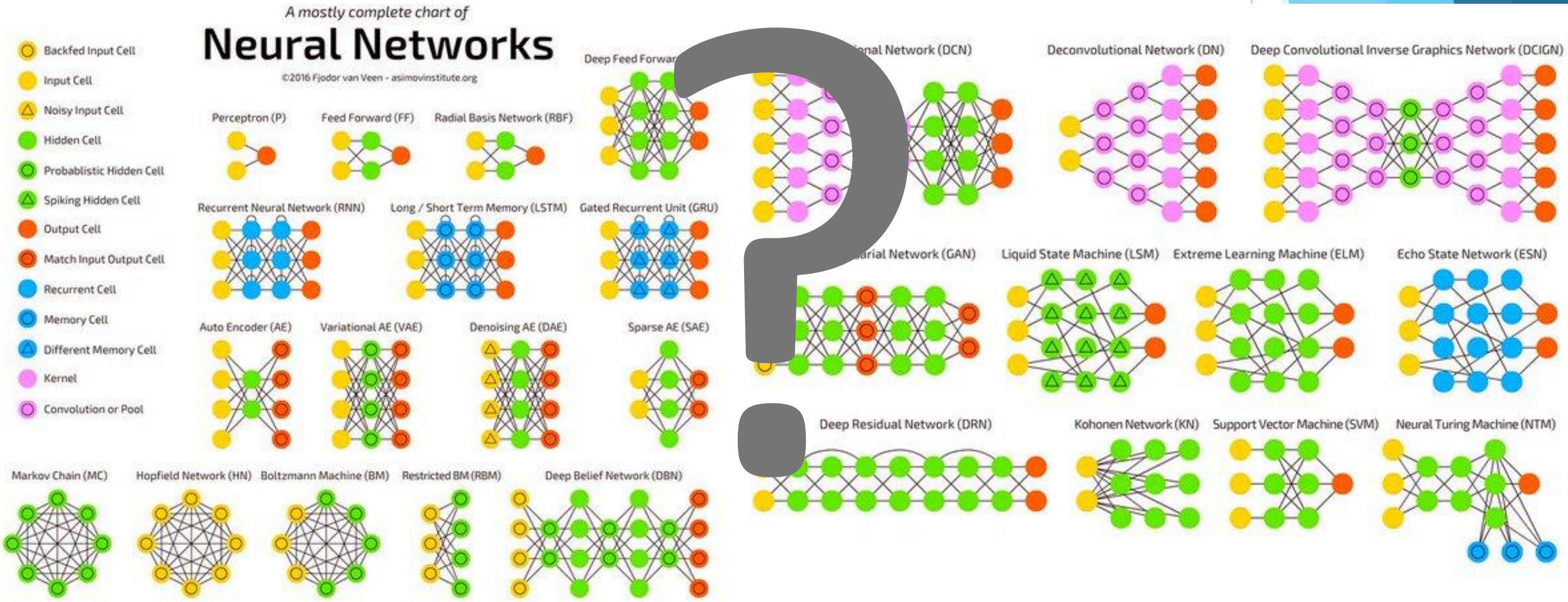
3

Model Selection & Hyper-Parameter Tuning

Key Ideas: The type of model and the hyper-parameters of the training algorithm must be chosen – this can be done automatically if the training is fast enough.

Model Selection

Which kind of model and topology is best for the task at hand? This is usually a trial-and-error problem.



Hyper-Parameter Tuning

The parameters of the training algorithm need to be tuned – also a trial-and-error problem.

Hyper-Parameters

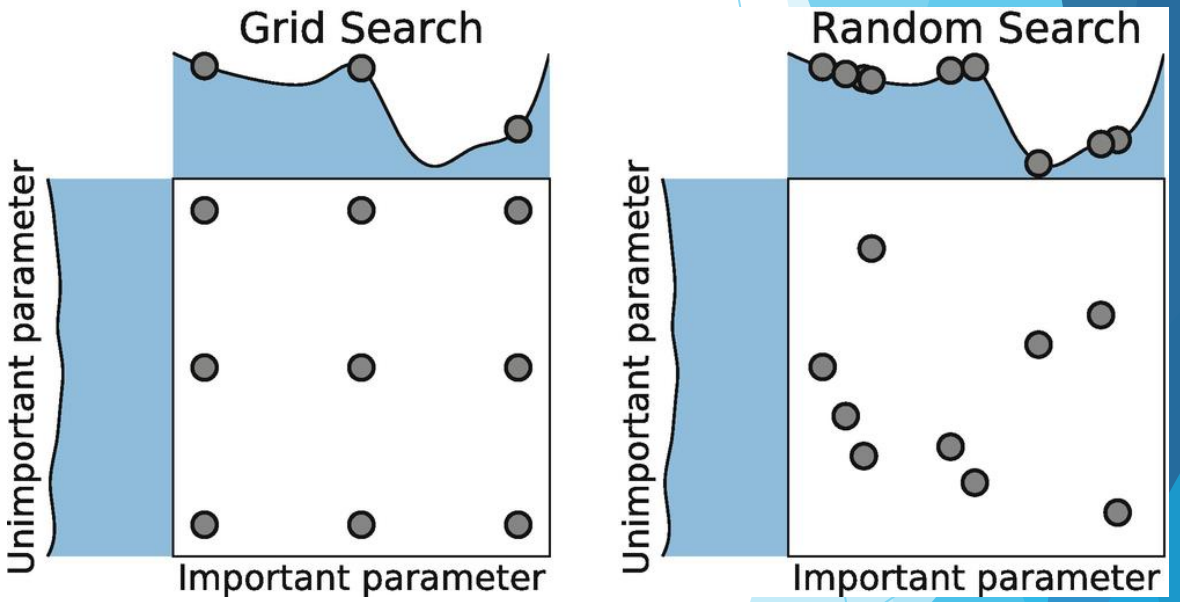
- Learning Rate
- Momentum
- Minibatch Size
- Number of Epochs
- Drop Out

Trial-and-Error done the Smart Way

Both trial-and-error problems are usually done manually with effort and few trials – let's do it automatically with many trials and smart adaptation.

Adaptive Search

- **Normal Way**
  - Sometimes we do not tune at all
  - Sometimes we select a few parameters manually, and take the best after experiments
- **New Way**
  - Let an adaptive algorithm automatically select the next experiment to run
  - Take the best alternative with confidence and objective assessment
- **Works both for model selection and hyper-parameter tuning**



4

Distributed Training

Key Ideas: Training a model on one computer takes a long time. So let's train it on many computers simultaneously. We can expect to get linear scaling performance – without the IT headaches of setting it all up.

Save time on Infrastructure Setup and Maintenance

Setting up your own cluster, maintaining it, and deploying your code on it requires several tools and lots of your time.

TensorFlow
PyTorch
Keras
kubernetes
SWAGGER
HELM
NVIDIA
docker
HOROVOD

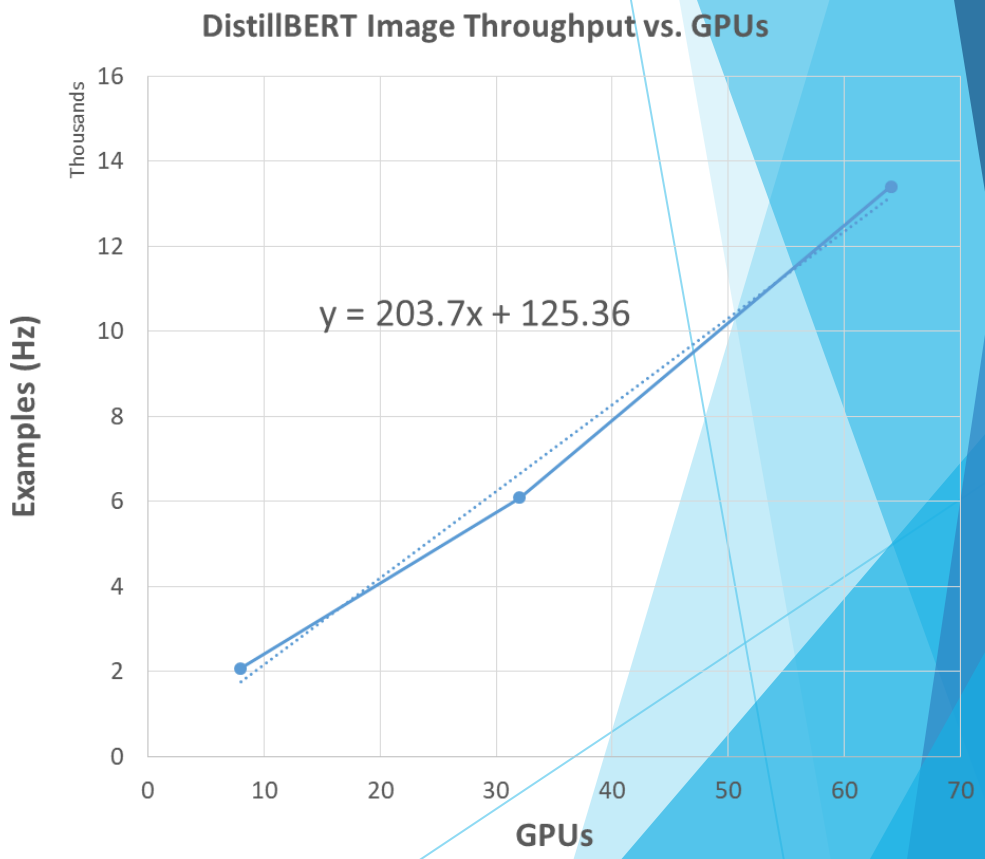
pick your language → no worries about infrastructure → run script → see results

Distributed Training Can Scale Linearly

By using multiple machines, AI Accelerator can reduce training times linearly, as demonstrated in the DistilBERT Huggingface benchmark.

DistilBERT Benchmark

- DistilBERT is a natural language model.
- Compared to training it using a single machine (8 GPUs), we achieve a speed-up of
  - **3x** by going to 4 machines (32 GPUs)
  - **6.3x** by going to 8 machines (64 GPUs)
- Further 2x speed-up can be realized by using AI Accelerator's special technique for communicating between GPUs during training.
- Total speed-up of 13.6x by going from 1 to 8 machines



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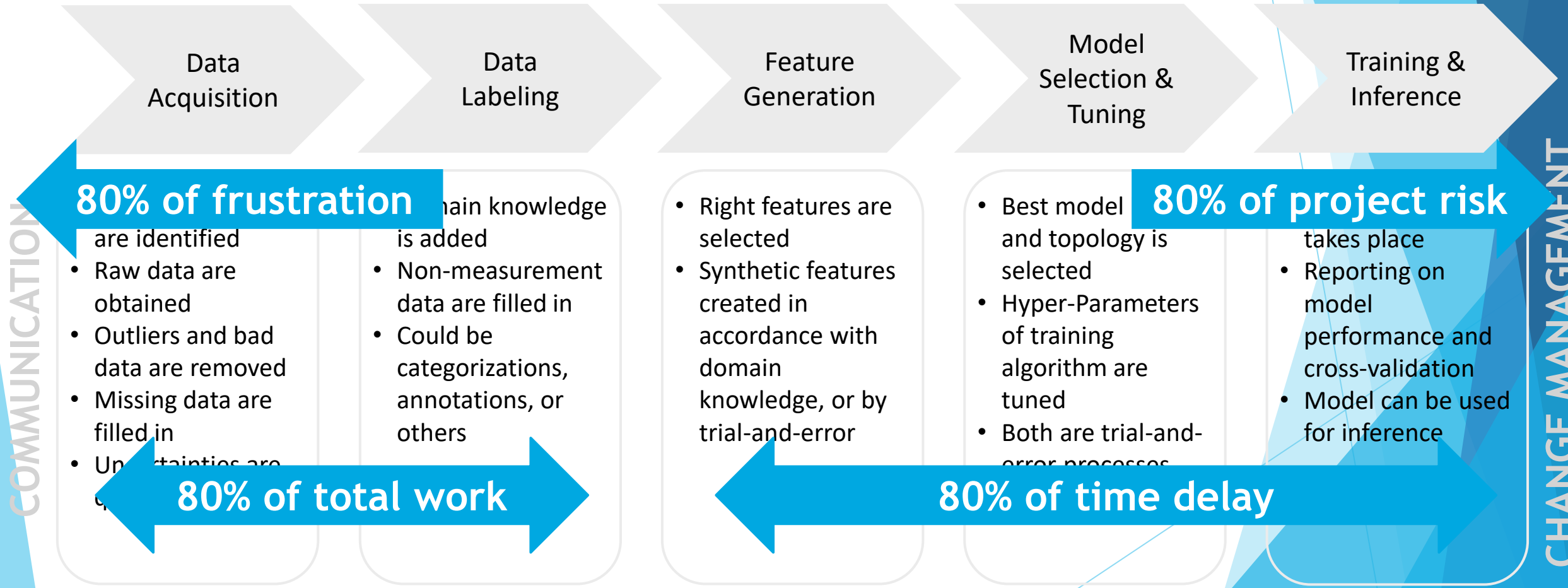

Acknowledgements, Thank You & Questions

Questions? Feel free to reach out. Find details and case studies in my books.

Patrick Bangert, VP of AI

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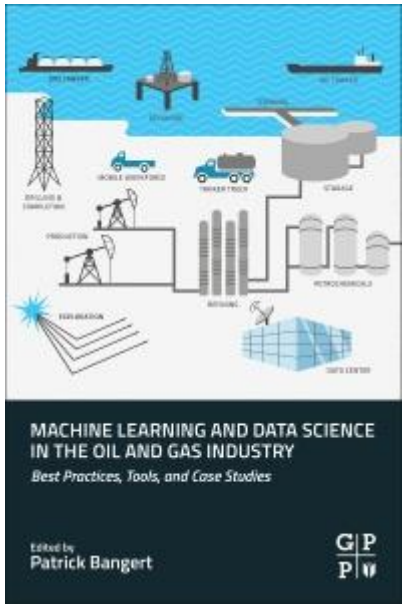

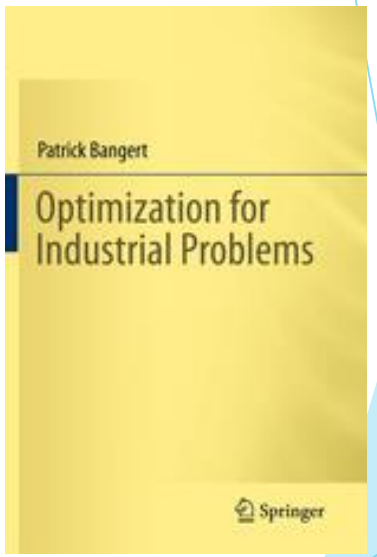

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