

QoS of production lines with predictive models

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Modelling of QoS for production lines

- Production process is decomposed to functional blocks with inputs/outputs
 - Inputs – material/energy inputs, control actions
 - Outputs – material/energy outputs, measured variables, diagnostic events
- The quality of service is defined using **key-performance indicators**
 - Mapped to outputs
 - Global for whole production line

Predictive models

- From the historical data inputs/output pairs (x_i, y_i) , we will find function $f(x)$ which will predict y for new inputs x
- Difference between predicted value $f(x)$ and expected value y is measured by **loss function** – $f(x)$ should minimize loss on whole population of (x, y) pairs drawn from the same unknown probability distribution
 - General loss functions – 1/0 loss, square error
- We cannot estimate generalized loss – **empirical loss $L(f)$** on independent test set

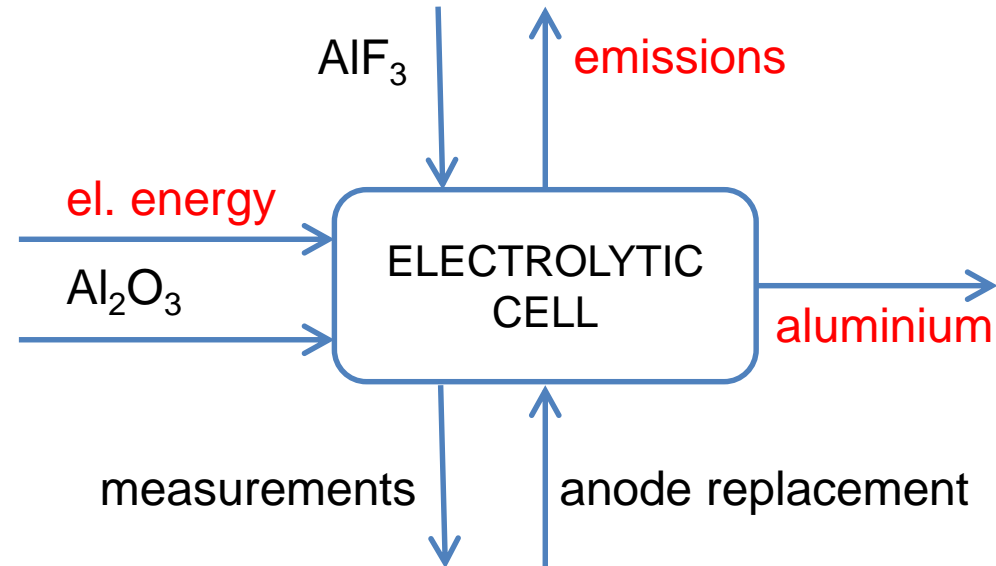
Optimization of the production process

- We will integrate prediction model $f(x) = y$ as a new functional block
- Predicted value y will influence global key-performance indicators – **link function** between KPIs and loss function used for the f optimization
 - The best situation – link function is identity and we are directly optimizing global KPIs
 - But this usually require specific algorithms for learning of f

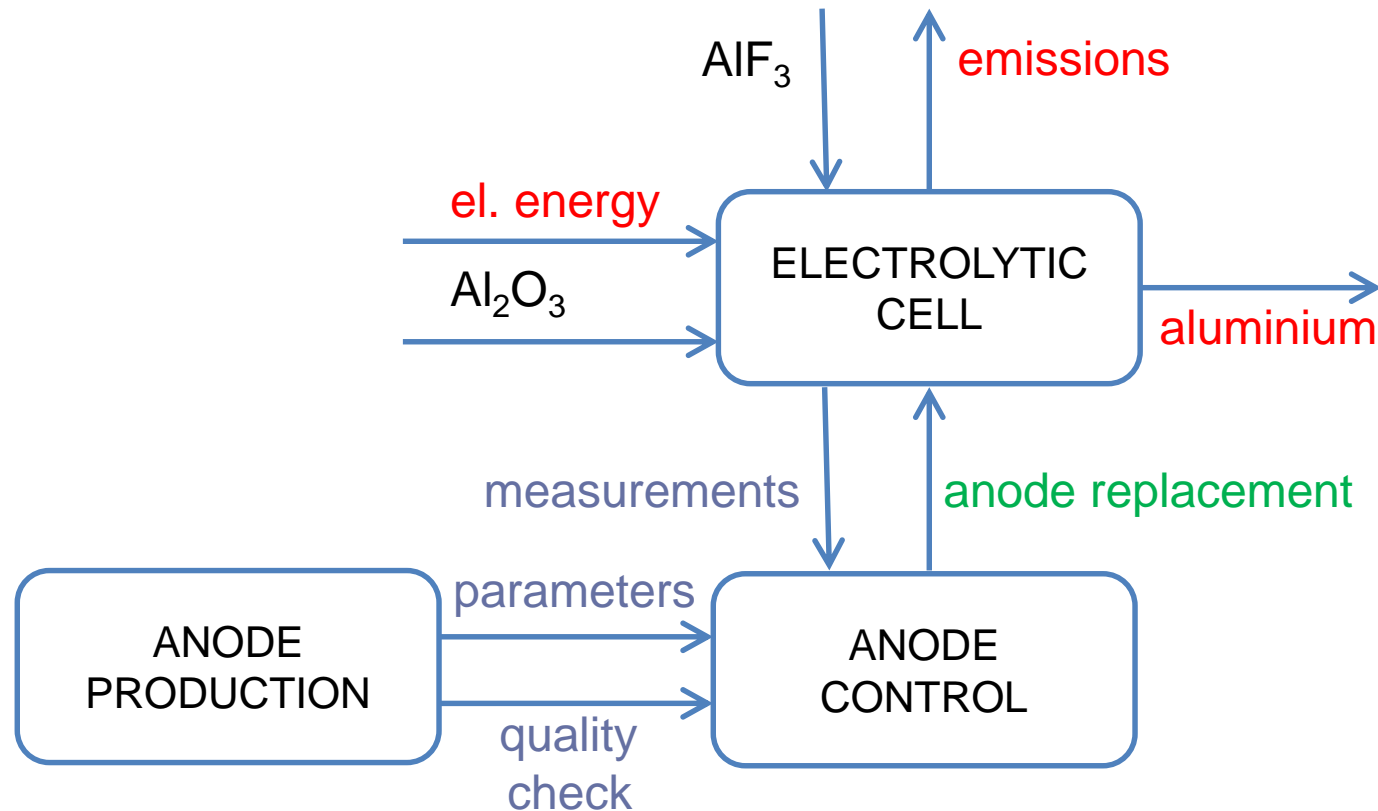
Quality of inputs

- Generally, predictive functions depends on training data + inputs included in the model
- Quality of training data – difficult to estimate directly
- Quality of inputs – in some cases, we can estimate how relevant/important are the inputs for the prediction
 - Generally you can use at least wrapper method – try to add/remove some input variable and estimate impact on the test set
- But in real environment, there can be a cost associated with the input – so for each input variable we can define **input cost function**

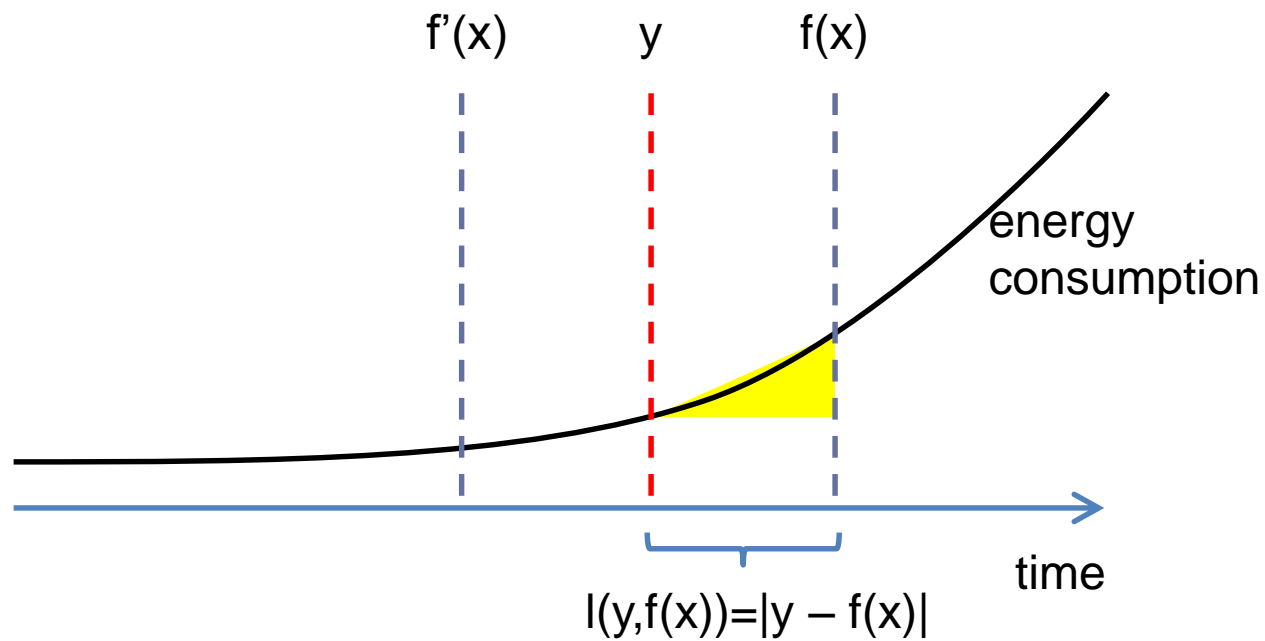
Example – production of aluminium (1)



Example – production of aluminium (2)



Example – production of aluminium (2)



Some conclusions

- We need modular models for processes with locally integrated predictive functions
 - But we are optimizing process global KPIs
 - And we have to consider costs for inputs (not only quality)