White Paper

Calculating the ROI of an AI Data Exploitation Project

Industrie 4.0 — www.efficientplant.com/services

Efficient Plant

Industrie 4.0 is a journey towards increased digital maturity. Most companies, especially SMEs, are only at the first stages. One thing that often creates a barrier to progress is the difficulty to economically justify level 4-5 projects, i.e., prediction and optimization projects using AI type tools, based on, and exploiting, the data infrastructure (and their visualization / transparency) put in place at levels 1-3 (*for more details on levels of digital maturity, see our publication: http://efficientplant.com/modele-4-0/*

LEVEL		DATA/PROCESSES
N1	Artisanal	Manual, partial, one-off, raw
N2	Descriptive	Historiorized, structured
N3	Diagnosed	Contextualized, understood
N4	*Predictive*	*Simulated*
N5	*Prescriptive*	*Optimized*
N6	Adaptive	Independent feedback

In this white paper, we will share how we approach this problem in four steps, adjusted depending on whether the chosen approach is one of prediction or optimization.

Approaches

One must recognize that the two situations (prediction and optimization) have their own associated challenges and thus require a different approach:

1 PREDICTION

If AI is used to establish a **prediction** in order to facilitate decision making, advanced analytical methods, machine learning, etc. will be used. Before assessing the decision's impact, the effectiveness of the predictive model needs to be assessed.

Typical Applications:

- ✓ Predictive maintenance
- ✓ Process behaviour prediction
- ✓ Demand forecast

2 OPTIMIZATION

If AI is used to decide on an **optimal choice** (in the case where there are an exponential number of possible solutions), operational research (OR) approaches are favoured, i.e. simulation and optimization algorithms where decisions greatly depend on the optimization objective.

Typical Applications:

- ✓ Dynamic scheduling (APS)
- ✓ Logistical optimization
- ✓ Operational performance optimization
- ✓ Optimization of production lines (routings)

Hereinafter, we will show how our four steps apply to each of these situations.

Prediction Scenario

A Sample and Efficiency Grid

We start by choosing a **sample of cases representative** of the situation that we wish to predict. This is where data captured and recorded at maturity levels 1-3 become crucial, especially once we have made sure that they have been characterized, quantified and, if necessary, adjusted.

We use data representing (or extrapolated to represent) **one year of activity**.

This allows us to put together an **efficiency grid**. The efficiency grid is a simple matrix that compares predicted results with actual results and makes it possible to distinguish false positives and false negatives from accurate predictions.

Each case in the grid represents **the number of cases of each type**. The model's degree of accuracy can be seen at a glance (greater refinement can be obtained by measuring the dispersion of predictions vs. an acceptability range).

	Prediction: Positive	**Prediction: Negative**
Actual result: Positive	**Correct** positive prediction 9	**False** negative prediction 2
Actual result: Negative	**False** positive prediction 6	**Correct** negative prediction 83

**numbers based on a sample of 100*

Impact Measurement B

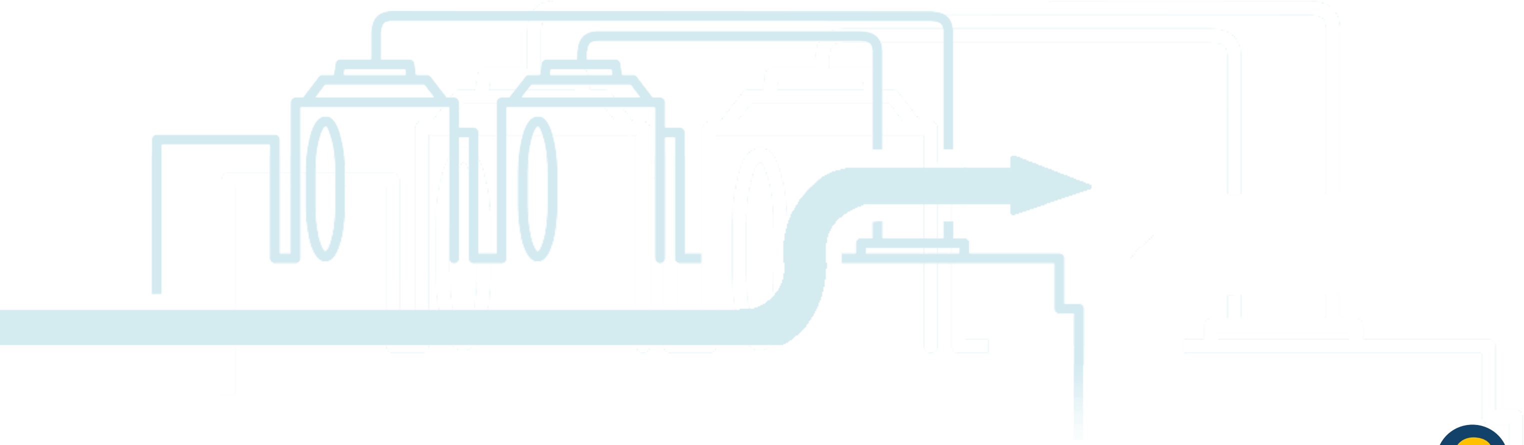
Next we move on to the financial side. The financial impact of each situation is quantified, i.e., the average gains/losses incurred for a single case in each efficiency grid cell:

FOR EXAMPLE:

Calculating the monetary impact of a breakdown or production failure enables a $50K lot to be saved by taking preventive action costing $5K, but which may incur $40K in correction costs in the event of an unforeseen breakdown.

Impact in $ = Gain (or avoided cost) - (Implementation cost/Additional prevention cost)

- For the 'Correct positive prediction' cell: the impact = avoided loss of product in the event of unforeseen breakdown ($50K) - prevention cost (e.g. additional ingredient added or more frequent and precise testing $5K) = $45K
- For the 'False positive prediction' cell: idem, i.e., avoided loss (none) and same cost (a loss was predicted) = $45K
- For the 'Correct negative prediction' cell: the impact = avoided loss of product as there was no problem ($50K) - no prevention cost as no problem was predicted ($0K) = $50K
- For the 'False negative prediction' cell: the impact = loss of product not avoided (-$50K) + cost of correcting the unforeseen problem (-$40K) = -$90K



Value Calculation C

We can then calculate the net financial 'value' of our predictive model. This is achieved by calculating the total impact (**on an annual basis**):

Total net value ($+ or -)* = Sum (no. of cases in each cell x Impact in $)

TAKING THE PREVIOUS EXAMPLE, WITH A SAMPLE OF 100 CASES:

	Prediction: Positive	Prediction: Negative
Actual result: Positive	45*9 = 405	-90 * 2 = -180
Actual result: Negatif	6*45 =270	83*50 = 4150

A total net value* of *4645k$* per year — *A **total net value of **4645k$** per year

D Analysis and Decision

Making your decision is a two-step process:

- Identify the option showing the best **net value**. To this end, we will calculate the **net value of other scenarios** not using the predictive model, i.e.,:

  - Status Quo

  Total Value = (-11*45 + 89 *50) = 3460k$

  (as if we were predicting that there would never be any problems)

  - Any other corrective action

  (for example, implementing a mitigation measure 100% of the time — i.e., not limiting it to situations where the model has predicted it to be necessary)

  Total Value = (11*45 + 89 *45) = 4500k$

  (as if we were predicting that there would always be a problem)

  We then identify the option with the best total net value: in the above example, the AI project has the best net value. However just because there is a possible gain does not mean that it is a good investment.

- We then calculate the **recovery period:** we compare the net value gain relative to the status quo with the investment required to produce this gain. For example, if the required investment is $1000K:

  Recovery period = required investment (1000) /Gain in value (4645-3460) = 10 months

  The project is chosen if this period is less that the maximum acceptable to the company.

Optimization Scenario

In order to choose an optimal solution from a (often very large) number of possible combinations, the following need to be identified from the start:

1. The **variables** to be taken into consideration and the **constraints** to be followed (i.e., the conditions that the optimal solution must fulfill).
2. The **objective function**, i.e., the KPI that we want to optimize:
   - This is the function that will serve as the criterion for determining the best solution for our optimization problem. The purpose of the optimization method is thus to minimize/maximize, this function to an optimum.
   - Note that a '*score'* can even be optimized based on a weighted combination of many KPIs.

A Sampling and Efficiency Test

A **sufficient number of cases** need to be chosen for evaluation, based on:

- historical data, or
- fictional but representative cases

As there are no false positives/negatives, this efficiency test is used rather to test several optimization methods on our sample in order to select the one providing the best results for the chosen KPI (and several others for information purposes).

Impact Calculation B

This is where the choice of objective function comes into play. **The monetary impact of any improvement/ worsening of the chosen KPI** must be established**:**

FOR EXAMPLE:

- For the KPI 'Make Span of a set of orders', the value of a saved production hour (or day) will be calculated. One basis of calculation could be the added value per hour created: (average sales price – average cost of MP) per hour;
- Likewise for the KPI 'Time Saved in set-ups', or number of hours (x average duration);
- For a measure of 'on time / late deliveries', things get more complicated: one way could be to estimate the probable value of the profit on future orders potentially lost, due to a bad reputation regarding this.

We measure these impacts in terms of annual savings.

Value Calculation C

In order to make the right decision, we have to know the impact of our choice on our objective. function.

The value of the gain/loss realized on the chosen KPI must be measured with regard to the reference scenario (current/manual method, or other):

Value= ΔKPI x Monetary Impact

D Analysis and Decision

The preceding steps enable us, by comparing the calculated value with the implementation cost, to calculate a recovery period:

Implementation Cost / Value

For example, if the project frees up 4 additional productive hours per week and that each hour has an added value of $500, you would save $100K annually (over 50 weeks).

If the project requires an investment of $200K, the recovery period will be 2 years. The project will thus be deemed acceptable if the company is seeking projects with recovery periods of two years or less.

Conclusion

Calculating the return on investment of an artificial intelligence based data enhancement project is not easy, but not impossible with the right approach. We hope that you will find these few pointers useful and, most importantly, that they will encourage you forge ahead.

Automation, Industrie 4.0 and more.

If you are faced with difficult to navigate operational problems, call us, we can help! Our mission is to provide the quality services that our clients need in order to build new factories, modernize existing facilities, optimize processes and apply new technologies in operating factories.

> ***A cost-benefit analysis should be used to shed light on a decision, not to make it.***
> *— Alan G Robinson*

Authors:

Bernard Boire
Director, Industrie 4.0
Efficient Plant Inc.

André Michel
President
Efficient Plant Inc.

Efficient Plant Inc. (EPI) is a consulting engineering firm specialized in the development, integration and operation of complex automated systems. EPI provides services in Industry 4.0, MES, process improvement, performance management, project management, technical support and training.

Efficient Plant Inc, 710-6600 Trans Canada Hwy,
Pointe-Claire (QC), H9R 4S2— (514) 947-1271
info@efficientplant.com— www.efficientplant.com