Using the BEAM Notation

This document shall provide quick-start information for using the BEAM notation. This document is structured as follows:

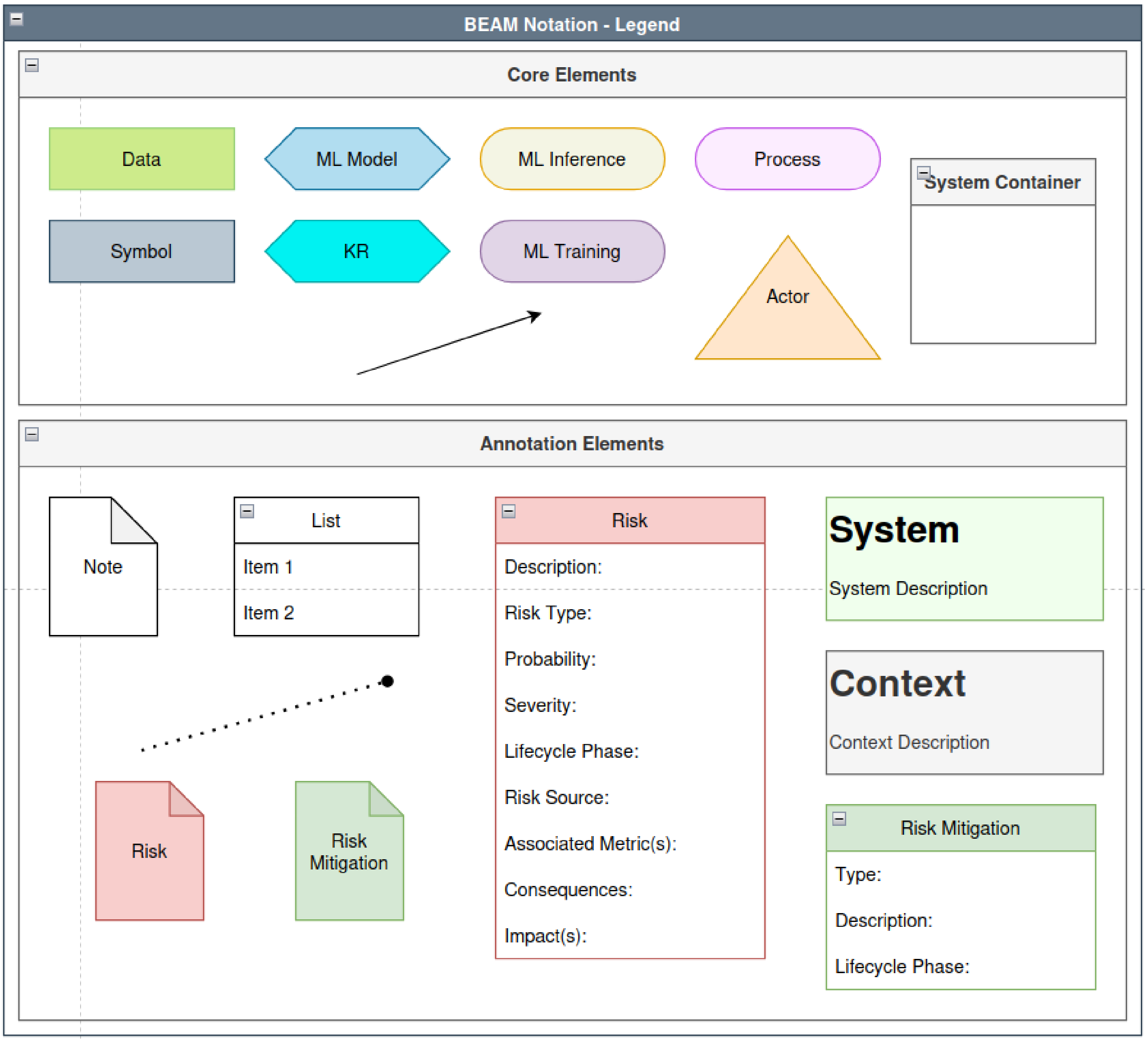
1. Setup

The boxology modeler is based on draw.io, a popular diagramming tool. Here are the necessary steps to prepare for modeling your solution:

1. **Install or access draw.io**
   To use draw.io, you have two options:
   a) Use the browser version at https://draw.io
   b) Download and install draw.io Desktop from https://get.draw.io
2. **Import the BEAM notation library [1]** that contains all the graphical elements
   a) Download the BEAM notation library in version 3 (beam_lib_v3.xml)
   b) Import the library (both desktop and online version): File > Open Library from > Device > [location of your downloaded file beam_lib_v3.xml]
3. **Start modeling**
   a) Access the library beam_lib_v3 on the top-left of your draw.io application in the shapes sidebar
   b) Start by adding the “Legend” component to your drawing by clicking it
   c) You can now draw from scratch by copy-pasting elements from the legend or by clicking the needed components in the shapes sidebar (top-left in the draw.io application)
4. **Save and submit**
   a) Save your file (*.drawio or *.drawio.xml)
   b) Submit your file via Canvas

2. Modeling

In the following, we will (briefly) explain the elements provided in the library (the grouping of the components is shown in the “Legend” box). It consists of



1. **Core drawing elements** used to represent the building blocks of your Data Science pipeline, including

a) Input/Output **Data** (green box), e.g. for text, tabular data, images, ...

b) **Symbol**ic Input/Output Resources (grey box), e.g. for knowledge graphs, …

c) **ML Model** (blue hexagon)

d) **Knowledge Representation and Reasoning** (**KR**, turquoise hexagon), e.g. for an ontology reasoner

e) **ML Inference** (light orange rounded rectangle)

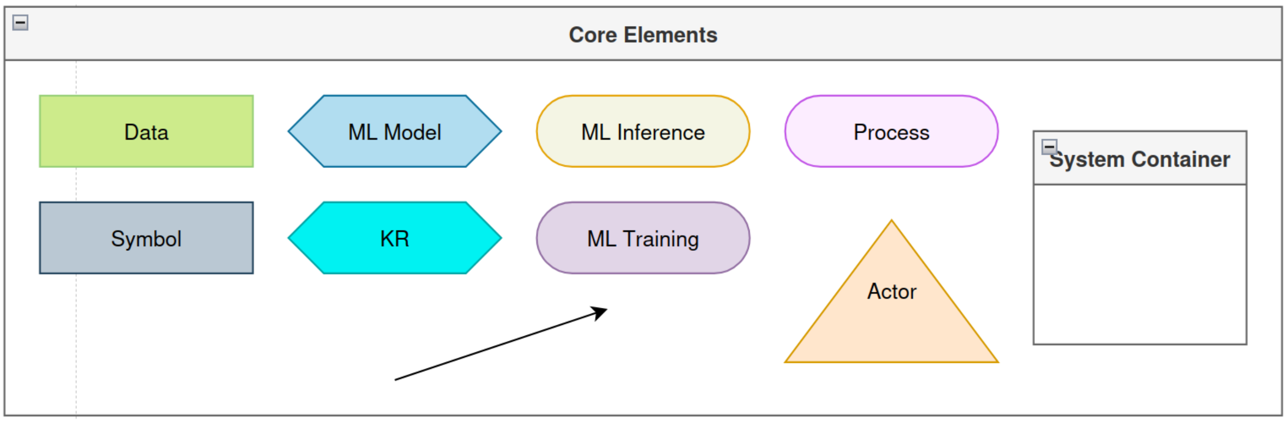
f) **ML Training** (purple rounded rectangle)

g) General **Process** Elements (pink rounded rectangle), e.g. for data preprocessing

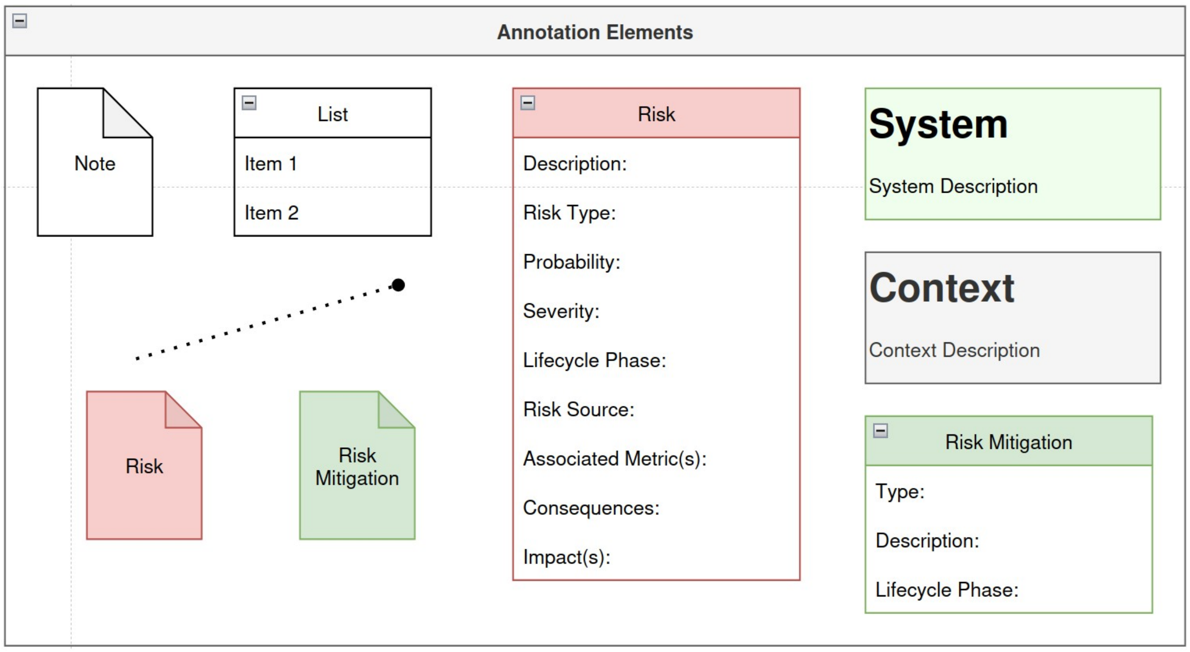
h) **Actor** (orange triangle), e.g. an engineer or user

i) **System Container**, for scoping different parts of the system

j) **Solid black arrow** to draw the connection/workflow between core components

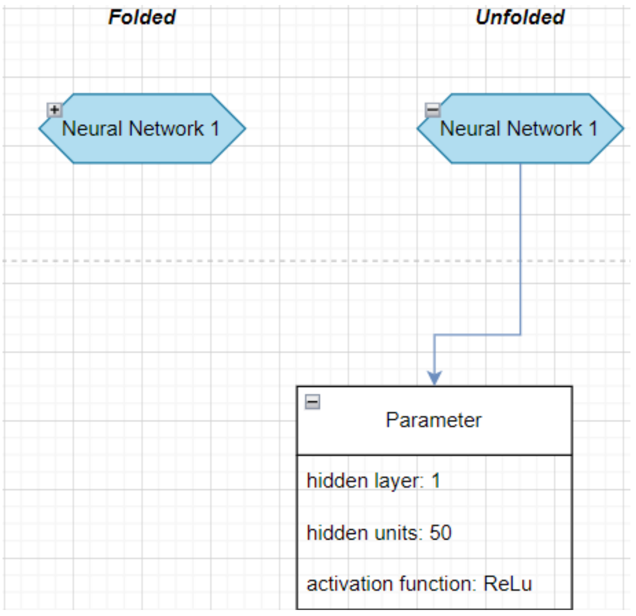


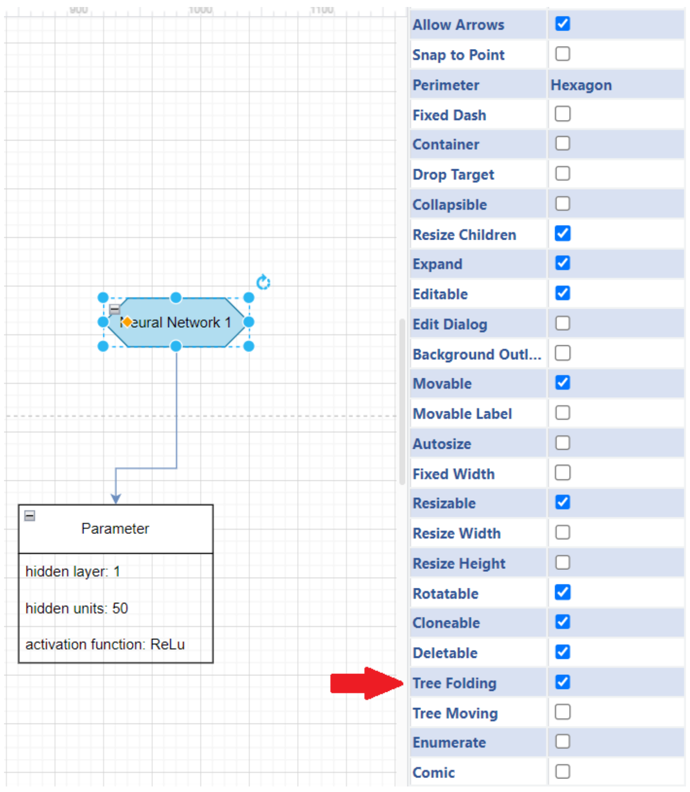
2. **Annotation drawing elements** used to annotating your Data Science pipeline building block, including
   a) **Note** to represent any free-text annotation
   b) **List** to represent list or key-value pair annotations
   c) **Risk** (as free-text or list) to represent risks associated with components or the system
   d) **Risk Mitigation** (as free-text or list) to represent risk mitigation for risks
   e) **System** and **Context** description to provide textual information of the system as a whole and the context it is operated in
   f) **Dotted arrow** to associate any of the above annotation elements to the relevant component



3. **Show/hide details**: In case the model contains details that should not always be visible, e.g. to hide them for an overview, this can be accomplished using the **Tree**

Folding property. The attached annotation details of elements with this property can be collapsed/expanded using the small minus/plus-icon on the element. Note: Unfortunately, draw.io does not support this for annotation details directly attached to container elements.



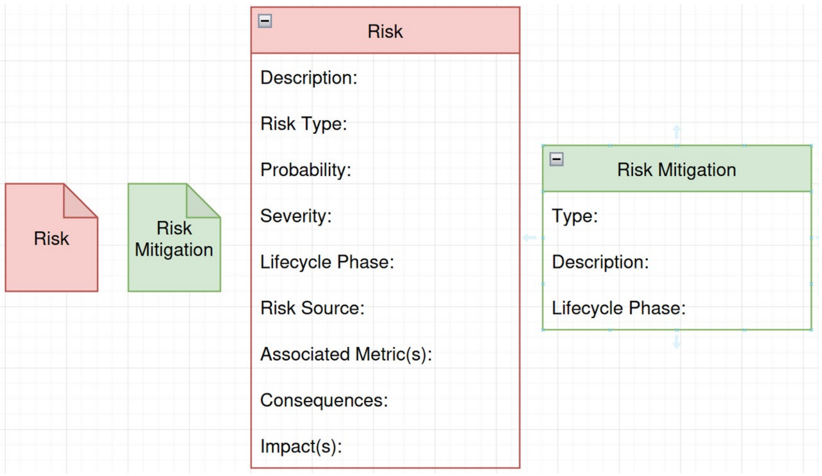


Allow Arrows	✓
Snap to Point	☐
Perimeter	Hexagon
Fixed Dash	☐
Container	☐
Drop Target	☐
Collapsible	☐
Resize Children	✓
Expand	✓
Editable	✓
Edit Dialog	☐
Background Outl...	☐
Movable	✓
Movable Label	☐
Autosize	☐
Fixed Width	☐
Resizable	✓
Resize Width	☐
Resize Height	☐
Rotatable	✓
Cloneable	✓
Deletable	✓
Tree Folding	✓
Tree Moving	☐
Enumerate	☐
Comic	☐

3. Modeling Risks and Mitigation

As described in the previous section, BEAM includes special annotation elements for representing risks and risk mitigation measures. Both can be represented as note-style elements for a free-text description of the risk/mitigation or more detailed list-style elements with explicit attributes. Risk elements are red, risk mitigation elements are green.

Guidelines and examples for the attributes of the detailed list-style risk and mitigation elements will be provided.



Risks can be associated to one or more elements using annotation connectors, this includes container elements. System level risks can represented by attaching risk elements to an overarching system container that includes the whole system.

Risk mitigation elements can also be associated to one or more elements using annotation connectors in the same way as risks (or other annotations). Often a risk mitigation measure will be associated to a specific risk, in which case this connection should also be modeled using an annotation connector. Risk mitigation elements, however, do not have to be connected to risk elements, and they can also be connected to risk elements and other elements of the system at the same time.

4. Example

We provided an example of a system in the BEAM notation, which is described below and can be downloaded at [2].

The depicted system is a classifier of fashion attire images. It is used in a recommender system of an online shop that sells fashion items. Users can upload images of fashion attire they like in order to receive similar recommendations.

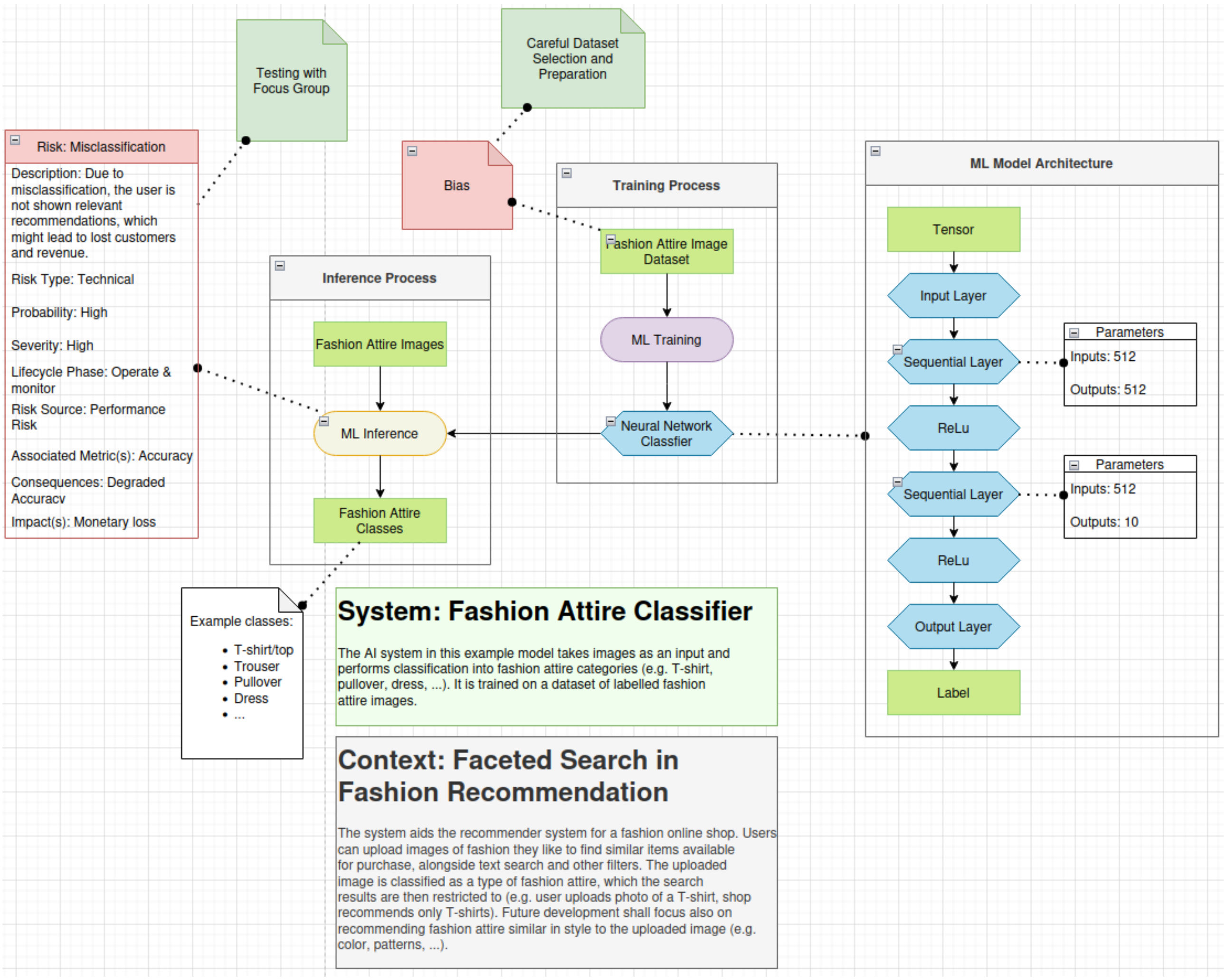
At the heart of the system is a machine learning model, which is trained on a dataset of labeled fashion attire images. The model is trained to classify which type of fashion attire an image shows, e.g. T-shirt, pullover, … The BEAM notation depicts the training and inference processes separately.

In the training process the aforementioned dataset is used to train the model. The internal model architecture is also depicted (an image is fed into the input layer of the ML model, with data flowing through the various layers of the model until the final layer produces a label as its output).

In the inference process, the ML model is used to classify the input images.

Two risks associated with this system are also modeled in the example. First, the dataset might contain some bias (for example there might be a disproportionate amount of pink dresses, which might cause the model to be biased towards classifying images of pink objects as dresses). This risk can be mitigated by selecting a high-quality dataset and/or additional preparation of the dataset.
The other depicted risk is that customers of the online shop might not be shown relevant items if the uploaded images are classified incorrectly. The mitigation strategy for this risk is to test the system with the trained model with a focus group of potential customers and evaluate the results.

The example furthermore includes a system and context description to provide a quick overview.



Description: Due to misclassification, the user is not shown relevant recommendations, which might lead to lost customers and revenue.

Risk Type: Technical

Probability: High

Severity: High

Lifecycle Phase: Operate & monitor

Risk Source: Performance Risk

Associated Metric(s): Accuracy

Consequences: Degraded Accuracy

Impact(s): Monetary loss

System: Fashion Attire Classifier

The AI system in this example model takes images as an input and performs classification into fashion attire categories (e.g. T-shirt, pullover, dress, ...). It is trained on a dataset of labelled fashion attire images.

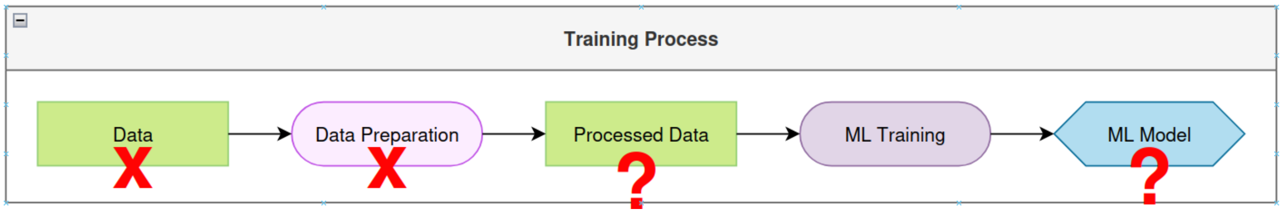
Context: Faceted Search in Fashion Recommendation

The system aids the recommender system for a fashion online shop. Users can upload images of fashion they like to find similar items available for purchase, alongside text search and other filters. The uploaded image is classified as a type of fashion attire, which the search results are then restricted to (e.g. user uploads photo of a T-shirt, shop recommends only T-shirts). Future development shall focus also on recommending fashion attire similar in style to the uploaded image (e.g. color, patterns, ...).

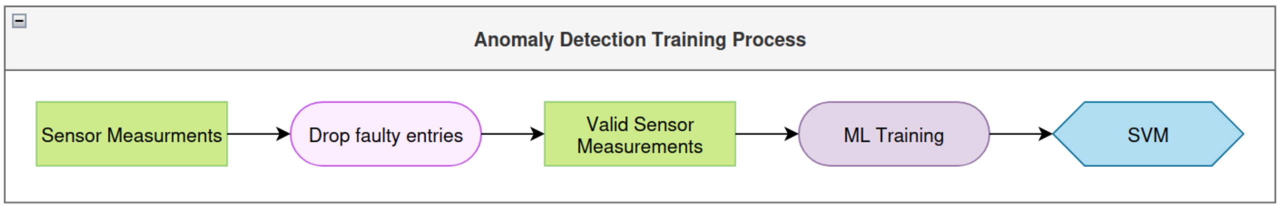
5. Dos and Don’ts – Best Practices

This section gives a few small examples with mistakes and how to avoid them.

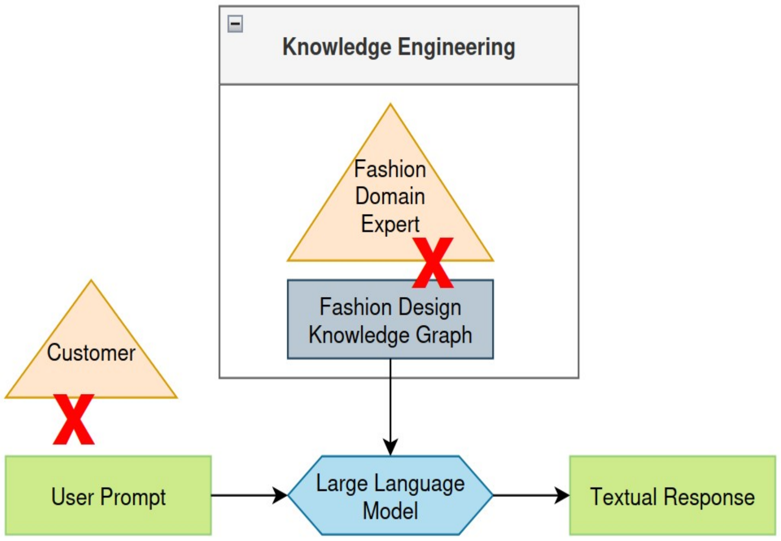
5.1 Example 1 – Unspecific Labels



In this example, very generic labels are used, s.t. the details of the modeled training process remain unclear. What type of data is used? Where does it come from? Data Preparation is too broad of a label, which concrete steps does the data preparation process consist of? Could the processed data be described more specifically? What kind of model is trained here? Below is the same example with more descriptive labels:

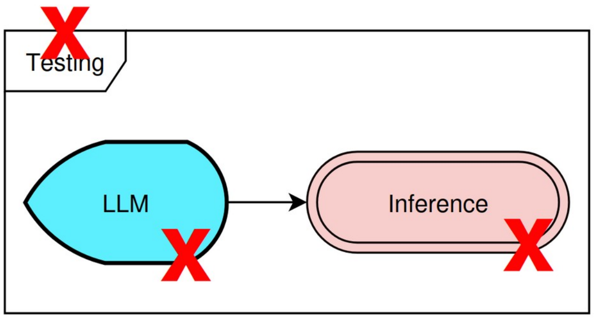


5.2 Example 2 – Missing Connectors



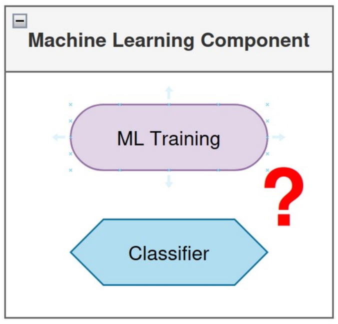
In this example, the actors are not connected to the rest of the model. Since BEAM models shall be automatically processable, the actors should be connected to the relevant elements using workflow connectors. Co-occurrence in the same container or proximity to the relevant elements are not enough – the workflow must be explicitly modeled.

5.3 Example 3 – Unknown Shapes



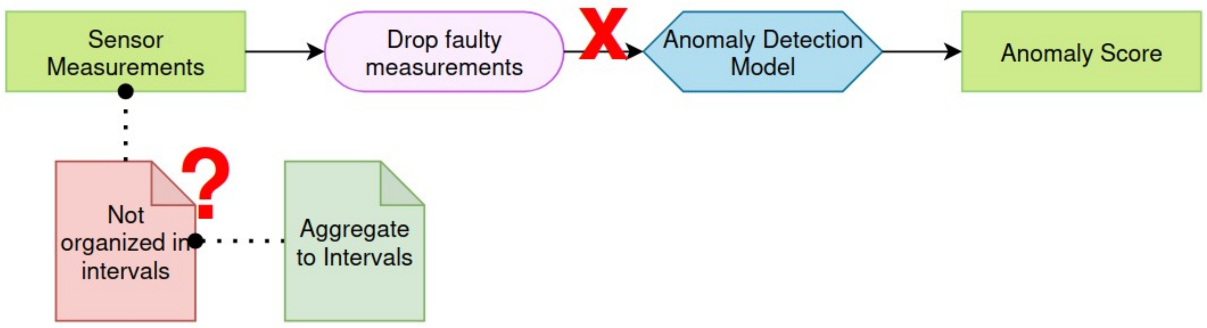
In order for BEAM models to be understandable for humans and automatically processable, elements that are not from the library shall not be used. This includes elements from other well-known modeling languages, such as UML.

5.4 Example 4 – Missing Elements and Connectors

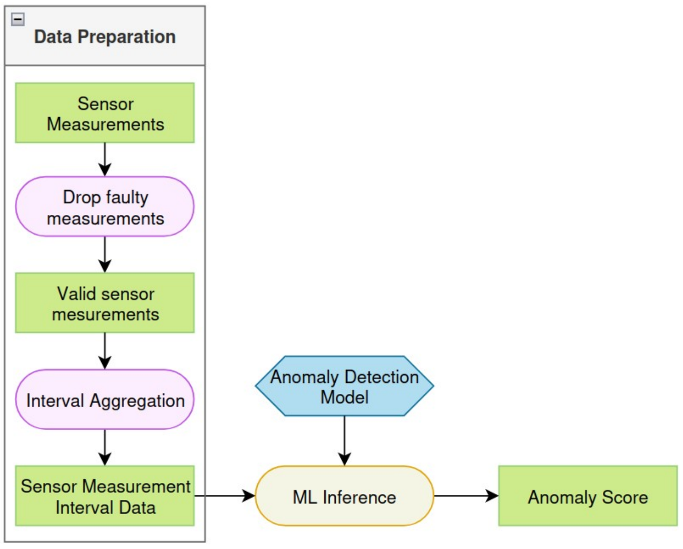


As mentioned in a previous example, an explicit connection between the training process and the classification model is missing. Furthermore, this example is missing input to the training process – which data is the classifier trained with?

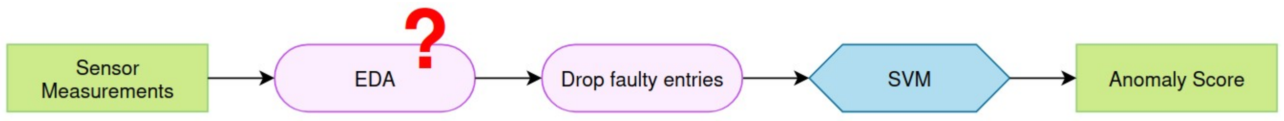
5.5 Example 5 – Missing Elements & Risk vs. Process



There are multiple issues in this example. Firstly, in case the input data (Sensor Measurements) is not always aggregated in a useful way, but there is an aggregation step, this should be modeled as a process and not as a risk with a mitigation strategy. Secondly, a process for data preparation (Drop faulty measurements) connects directly to the model and it is only implied that there is an inference process. The example below correctly represents the inference process and intermediary data output.



5.6 Example 6 – Represent AI system, not Engineering Process



In this example, exploratory data analysis (EDA) is included as a process in the workflow. BEAM is intended to model AI systems, not the engineering process behind it. It might also be helpful to ask what the output of a process is and to model it explicitly. In the case of EDA, the results might be descriptive statistics, data visualization and insights gained about the data – is this used in the AI system or in the engineering process?

6. References

[*] A more comprehensive documentation is available in the following link: https://github.com/wu-semsys/beam_tutorial/blob/main/beam_technical_documentation_v3.md

[1] https://github.com/wu-semsys/beam_tutorial/blob/main/beam_lib_v3.xml

[2] https://github.com/wu-semsys/beam_tutorial/blob/main/beam_v3_example_fashion_attire_classfication.xml