

## VALIDATION OF MACHINE LEARNING SERVICES

Do not let your Machine Learning service going into production without being tested

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May 20, 2019

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- 1 Introduction
- 2 Machine Learning
- 3 Building a Machine Learning Service
- 4 Testing the Service

## Introduction

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Do we really know what **Artificial Intelligence** is?

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And, specifically, do we know what **Machine Learning** is?

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How can we **verify** and **validate** services whose response depends on a Machine Learning model?

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2. **Understand** what is Artificial Intelligence and **Machine Learning**.
3. **Build a service** that relies on a Machine Learning model.
4. **Generate some tests** that verify and validate the service and the model.

*The glue*



*The glue*



*The shield*



*The glue*



*The power*



*The shield*



*The glue*



*The power*



*The shield*



*The mind*



# Machine Learning

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# What is Artificial Intelligence?

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Also known as artificial general intelligence. Is an AI system with generalized human cognitive abilities. When presented with an unfamiliar task, a strong AI system is able to find a solution without human intervention.

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## **Weak AI**

Also known as narrow AI. Is an AI system that is designed and trained for a particular task.

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## **Supervised learning**

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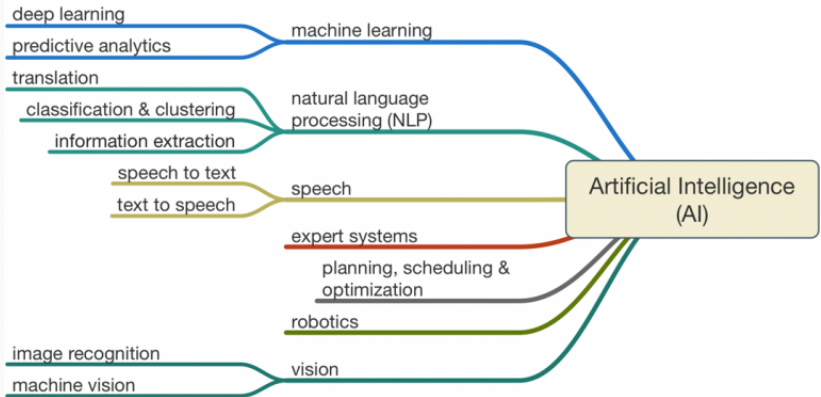
## **Unsupervised learning**

Data sets aren't labeled and are sorted according to similarities or differences.

## **Reinforcement learning**

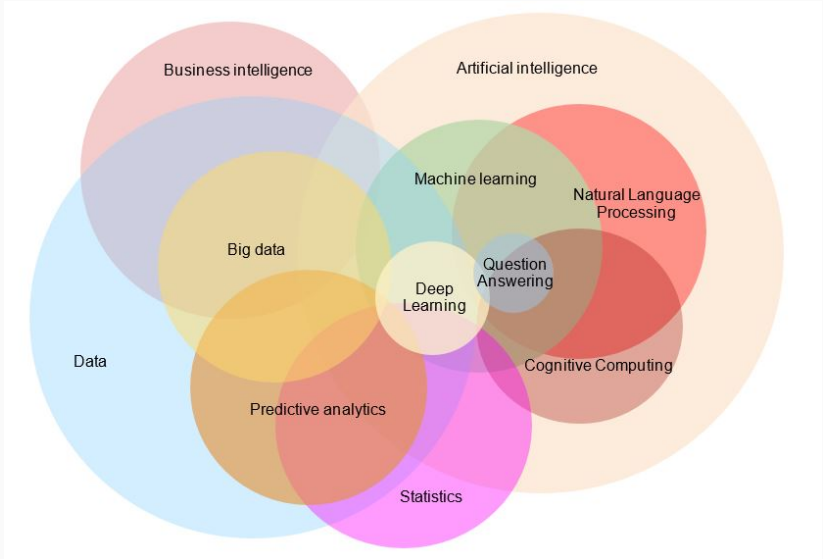
Data sets aren't labeled but, after performing an action or several actions, the AI system is given feedback.

# AI in perspective





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# AI in perspective

## Artificial Intelligence

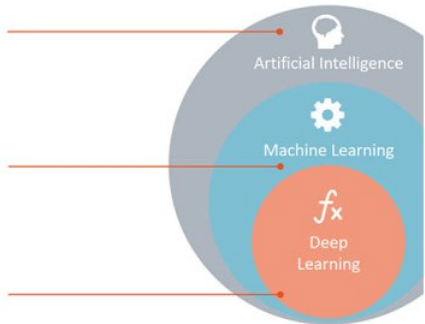
Any technique which enables computers to mimic human behavior.

## Machine Learning

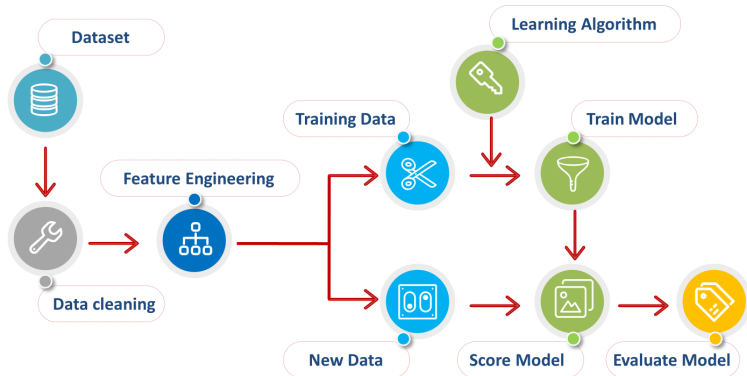
Subset of AI techniques which use statistical methods to enable machines to improve with experiences.

## Deep Learning

Subset of ML which make the computation of multi-layer neural networks feasible.



# Supervised Learning

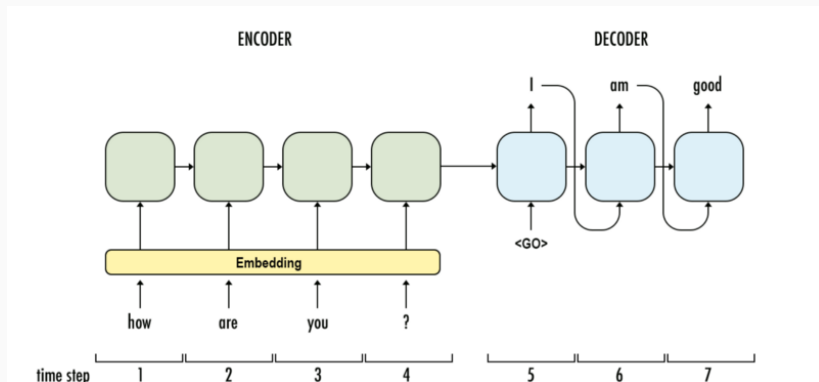


# The Model

We are going to build a model that performs a sentiment analysis over a text and concludes if it is positive or negative.

**Input:** A text (a list of integers representing each word).

**Output:** 0 (negative) or 1 (positive).



The dataset used for training this model is based on movie's reviews from IMDB.

Text input	Input	Output
the as you with out themselves...	[1, 14, 22, 16, 43, 530, ...]	1
the thought solid thought sena...	[1, 194, 1153, 194, 8255, ...]	0
the as there in at by br of su...	[1, 14, 47, 8, 30, 31, 7, ...]	0
the of bernadette mon they hal...	[1, 4, 18609, 16085, 33, ...]	1
the sure themes br only acting...	[1, 249, 1323, 7, 61, 113, ...]	0

## **Building a Machine Learning Service**

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## How to expose the ML model?

Machine Learning models can be used either as an internal piece of a service or as a service itself.

If it is used as an **internal piece** you won't notice it, such as scoring or recommendation systems within bigger products like Spotify or Netflix.

But you can also find them as a **service that exposes an API** to directly interact with the model. There are many examples of that in AWS, Google Cloud, Azure...

One of the most widely adopted way of serving a ML model is to wrap it into a **REST API** with specific methods for calling the model.



Our service will expose a single endpoint that let us interact with the model.

## Request

**Verb** GET

**URL** `https://service.url/analyze/`

**Params** `text=The girl is having fun while playing with her toys`

## Response

```
{  
  "score": 0.5628073215484619,  
  "text": "The girl is having fun while playing with her toys",  
  "sentiment": "Positive"  
}
```

To build a REST API we need to define:

1. A **component** that loads our ML model.
2. The **data schema** for our response.
3. The **view** function that will be called through requests to `/analyze/` endpoint.
4. The whole API **application**.

Everything put together is less than 100 lines of python code.

```
class SentimentAnalysisModel:
    def __init__(self, model, words: typing.Dict[str, int]):
        self.model = model
        self.words = words

    def predict(self, text: str) -> typing.Tuple[float, str]:
        x = text.lower().split()
        x = [self.words.get(i, 0)
              if self.words.get(i, 0) <= VOCABULARY_LENGTH else 0 for i in x]
        x = sequence.pad_sequences([x], maxlen=MAX_WORDS)
        score = self.model.predict(x)
        sentiment = "Positive" if self.model.predict_classes(x)[0][0] == 1 \
            else "Negative"

        return score, sentiment

class SentimentAnalysisModelComponent(Component):
    def __init__(self, model_path: str, words_path: str):
        self.model = load_model(model_path)
        self.model._make_predict_function()
        with open(words_path) as f:
            self.words = json.load(f)

    def resolve(self) -> SentimentAnalysisModel:
        return SentimentAnalysisModel(model=self.model, words=self.words)
```

```
class SentimentAnalysis(Schema):
    text = fields.String(
        title="text",
        description="Text to analyze"
    )
    score = fields.Float(
        title="score",
        description="Sentiment score in range [0,1]"
    )
    sentiment = fields.String(
        title="sentiment",
        description="Sentiment class (Positive or Negative)"
    )
```

# Analysis View

```
def analyze(text: str, model: SentimentAnalysisModel) -> SentimentAnalysis:
    """
    tags:
        - sentiment-analysis
    summary:
        Sentiment analysis.
    description:
        Performs a sentiment analysis on a given text.
    responses:
        200:
            description: Analysis result.
    """
    text = unquote(text)
    score, sentiment = model.predict(text)

    return {
        "text": text,
        "score": score,
        "sentiment": sentiment,
    }
```

```
app = Flama(  
    components=[SentimentAnalysisModelComponent("model.h5", "words.json")],  
    title="Sentiment Analysis",  
    version="0.1",  
    description="A sentiment analysis API for movies reviews",  
)  
  
app.add_route("/analyze/", analyze, methods=["GET"])
```

## Testing the Service

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The most common development cases of Machine Learning services are those where the building of the model and the service are done completely separated and even by different teams.

That implies we aren't in control of the training process so that we cannot test the model until both are merged.



# Validation vs Verification

Criteria	Verification	Validation
<i>Definition</i>	The process of evaluating products of a development phase to determine whether they meet the specified requirements.	The process of evaluating software during or at the end of the development process to determine whether it satisfies specified business requirements.
<i>Objective</i>	To ensure that the product is being built according to the requirements and design specifications.	To demonstrate that the product fulfills its intended use when placed in its intended environment.
<i>Question</i>	Are we building the product right?	Are we building the right product?

# Test Specification: Verification

```
## Endpoint Verification
Tags: functional, verification
```

Verify if the endpoint that allows interaction with Sentiment Analyzer is properly defined based on specifications. It must provide a query parameter `**text**` that acts as the input of the model and it cannot be empty. The response must be a JSON containing three attributes: `**text**`, `**score**` and `**sentiment**`.

- \* Request sentiment analysis with text "Perdy is testing this" returns "200"
- \* Response schema contains attributes

Attribute
text
score
sentiment
- \* Request sentiment analysis with text "" returns "400"

# Test Specification: Validation

```
## Model Validation  
Tags: ml, validation
```

Validate the model predictions against a set of fixed data. This data set must contains a minimum list of well-known pairs of input and output to check that after retraining the model it will continue behaving the same way against these inputs.

- \* Analyze and validate the following texts <table:data/sentiment\_analysis.csv>

## Step Implementation

```
@step("Response schema contains attributes <table>")
def assert_response_schema(table):
    response = data_store.scenario["response"]

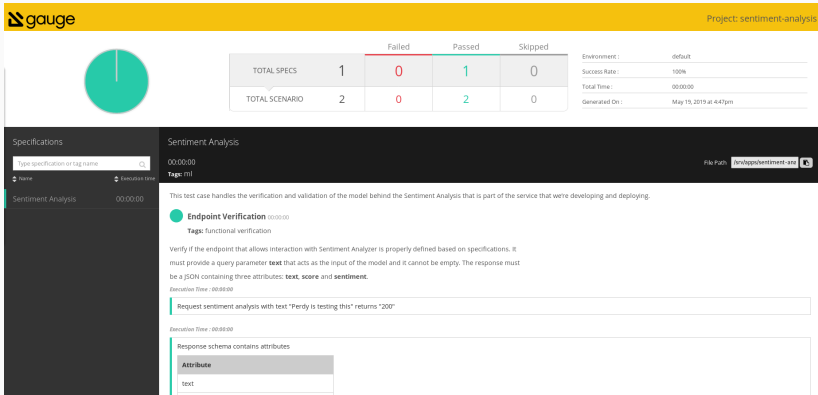
    for attribute in table.get_column_values_with_name("Attribute"):
        assert attribute in response
```

# Console Output

```
•100% → ./make test
# Sentiment Analysis
  ## Endpoint Verification      ✓✓✓
  ## Model Validation          ✓

Successfully generated html-report to ⇒ /srv/apps/sentiment-analysis/reports/html-report/index.html
Specifications: 1 executed      1 passed      0 failed      0 skipped
Scenarios:      2 executed      2 passed      0 failed      0 skipped

Total time taken: 505ms
```



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