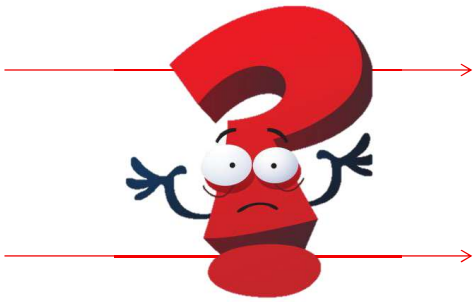
Machine Learning – How it works

Classical Machine Learning

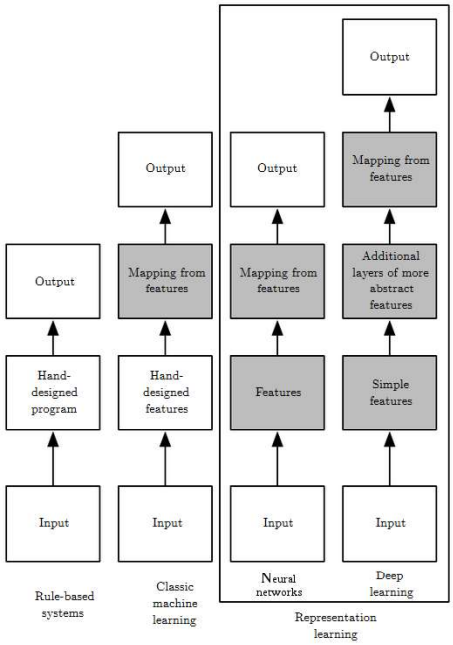


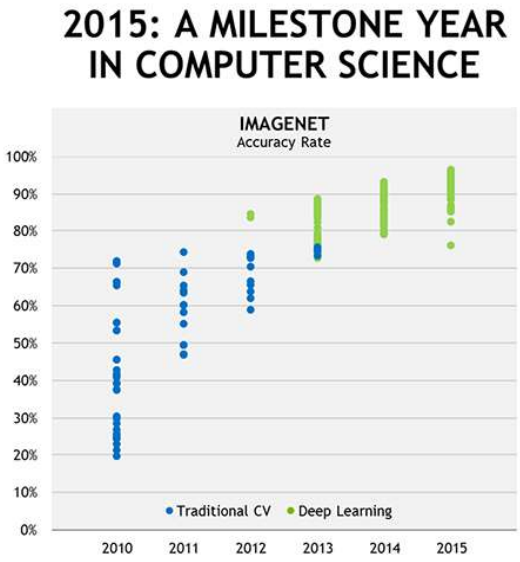
Cat

Burglar breaking in a house

How does my computer do it ???

Machine Learning – How it works





Machine Learning – How it works

Using the RGB pixels that compose the image?

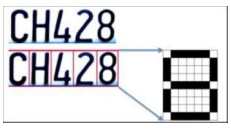
No! Not meaningful enough.
The picture of a cat can have a lot of different colors
Especially if we have the colors of the background

Machine Learning – How it works

Convert RGB pixels to meaningful numbers that can be understood by the machine (hand-crafted features)

=> Feature Extraction

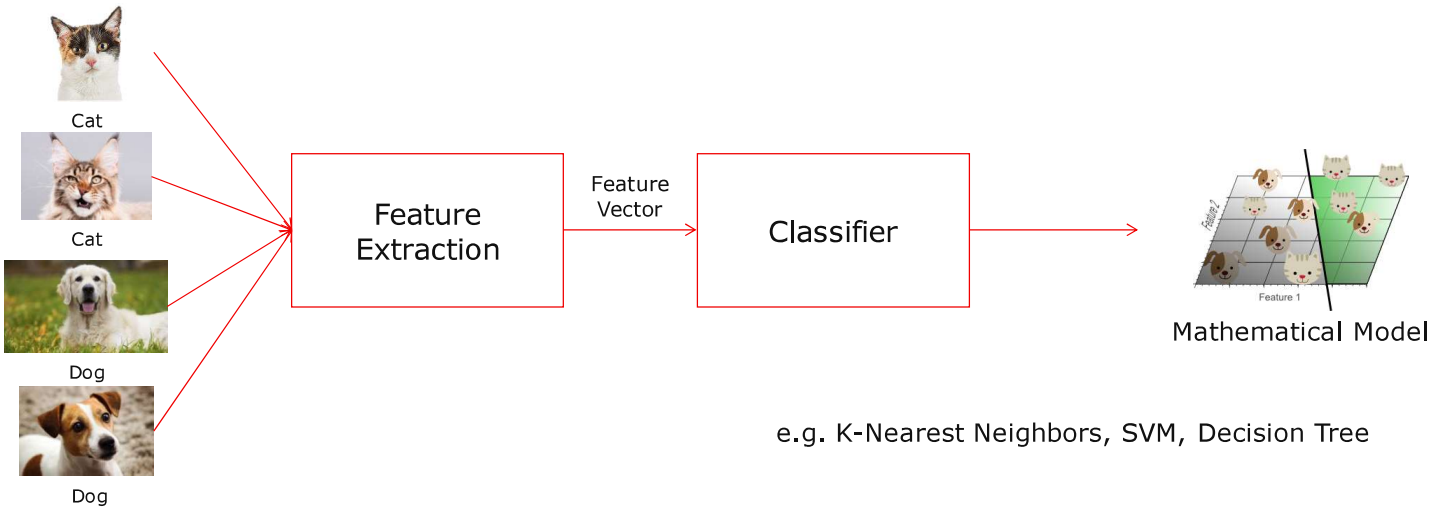
- Colors
- Shapes
- Points of interest
- Motion (video)
- Text/Numbers



Note: We can also build hand-crafted features for audio but that is not in the scope of this track

Machine Learning – How it works

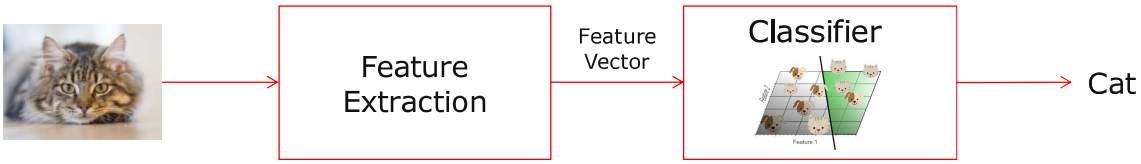
From meaningful features, we can learn patterns !
We feed what we call a "Classifier" with labelled data and it will build a mathematical model (Optimization). This is the training step.



e.g. K-Nearest Neighbors, SVM, Decision Tree

Machine Learning – How it works

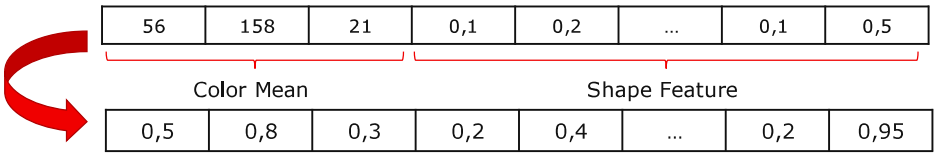
Once the classifier is trained (optimized mathematical model), we can Feed it with new samples and predict its label.



Machine Learning – How it works

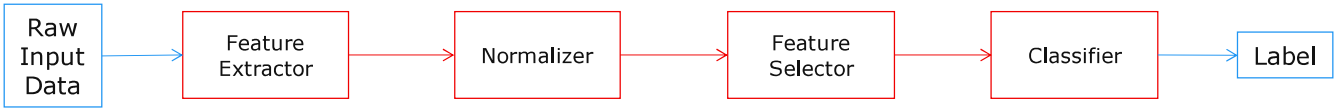
This pipeline is usually too simplistic to perform well

- Reducing the feature values is good for speed
- When concatenating feature vectors, some features can have larger values than others

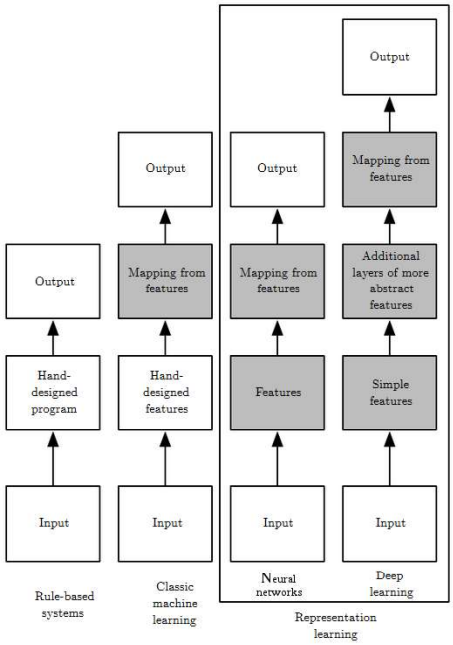


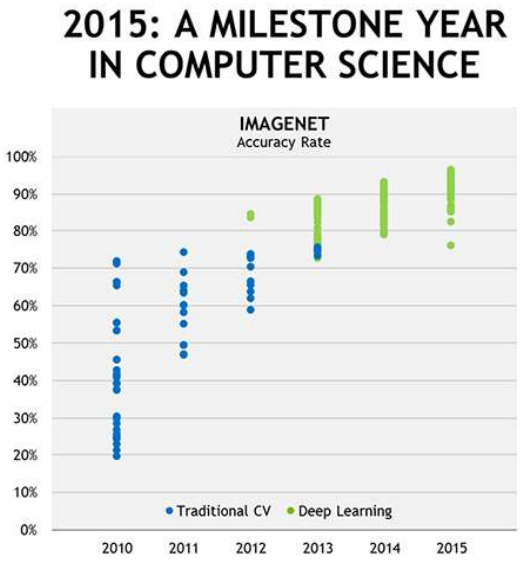
=> Normalize the feature vectors

- Select the relevant features only! E.g. Principal Component Analysis

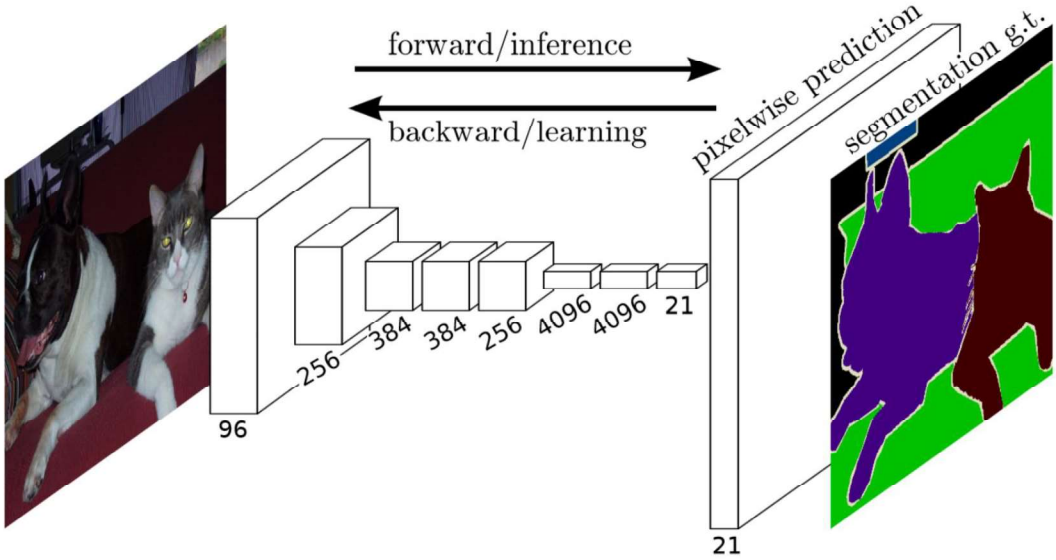


Machine Learning – How it works

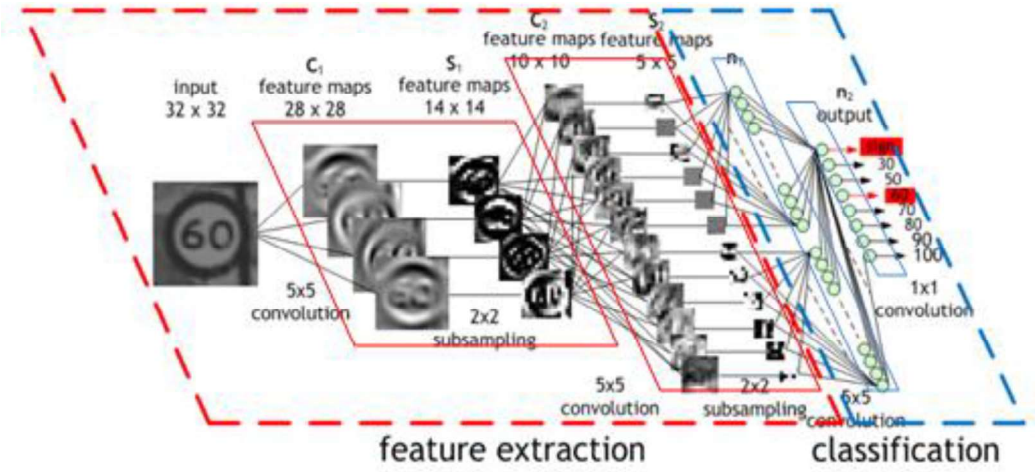




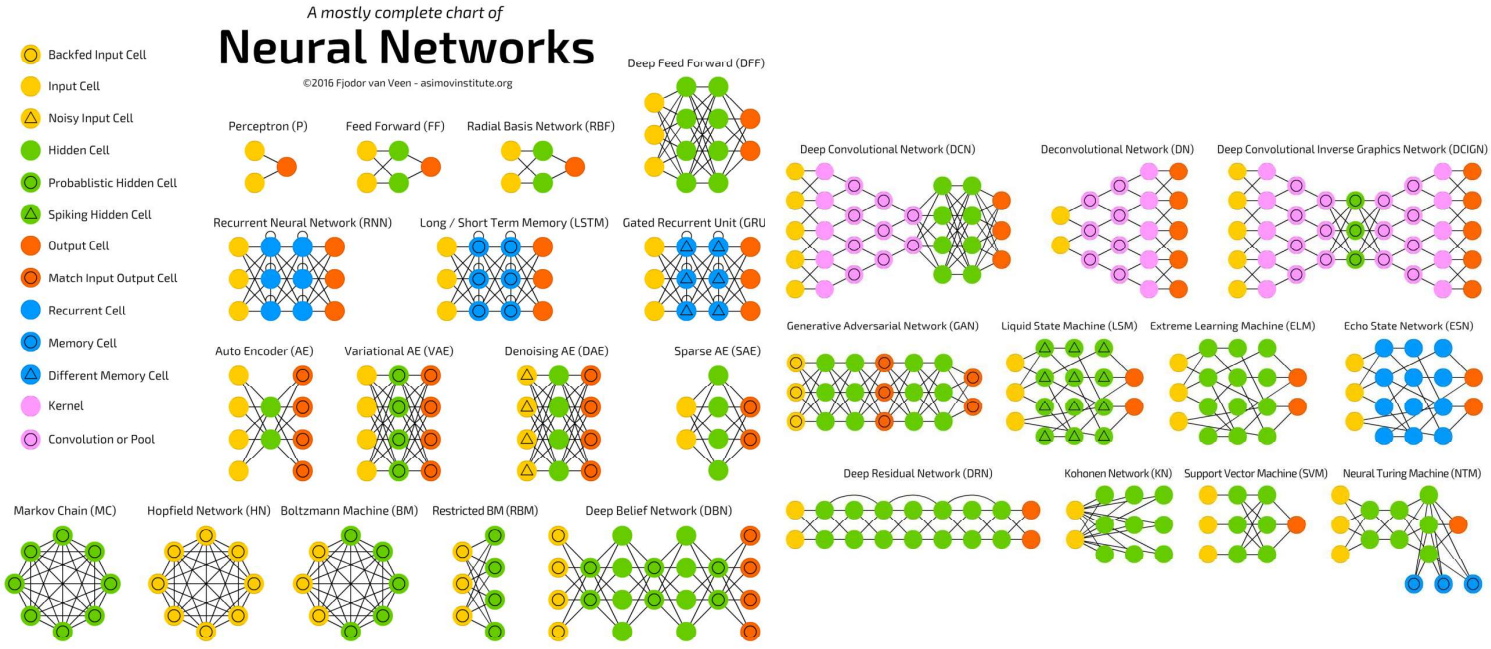
Machine Learning – in short



Machine Learning – in short

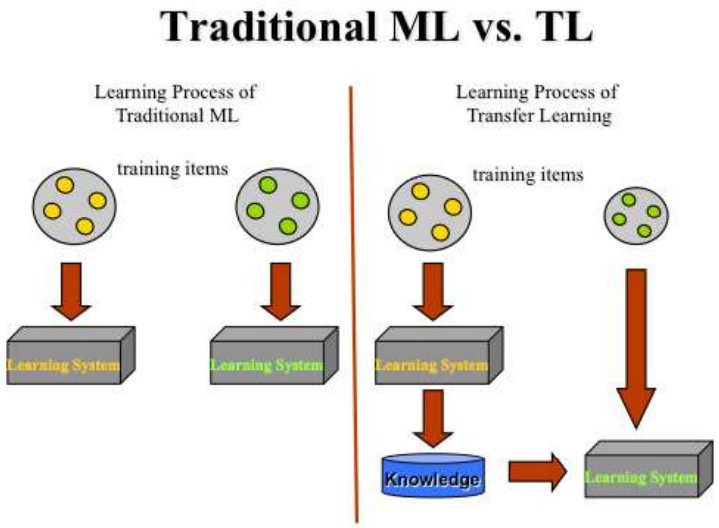


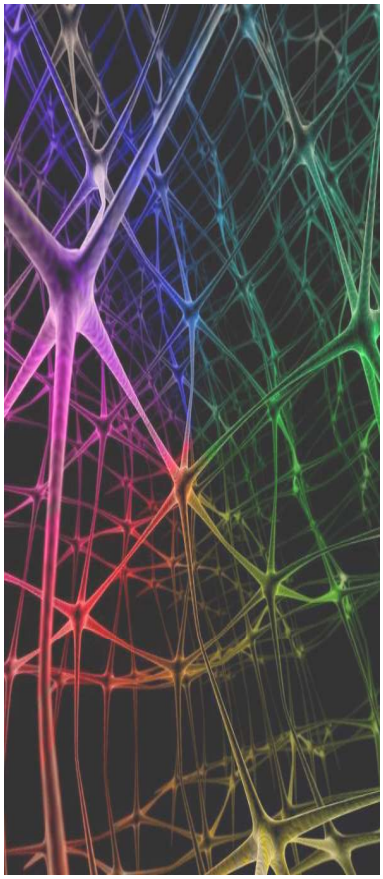
Machine Learning – in short



Machine Learning – in short

- Transfer Learning (TL)
- Start from a pre-trained model
  - No need to try architectures
  - Trains faster
  - Trains with less data





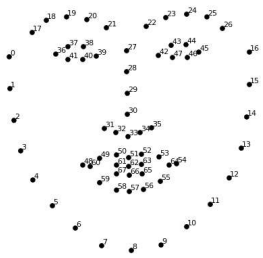
Questions?

About us? Barco? Machine Learning?

Hands-on – Introduction

Some Machine Learning, some coding and … some fun!

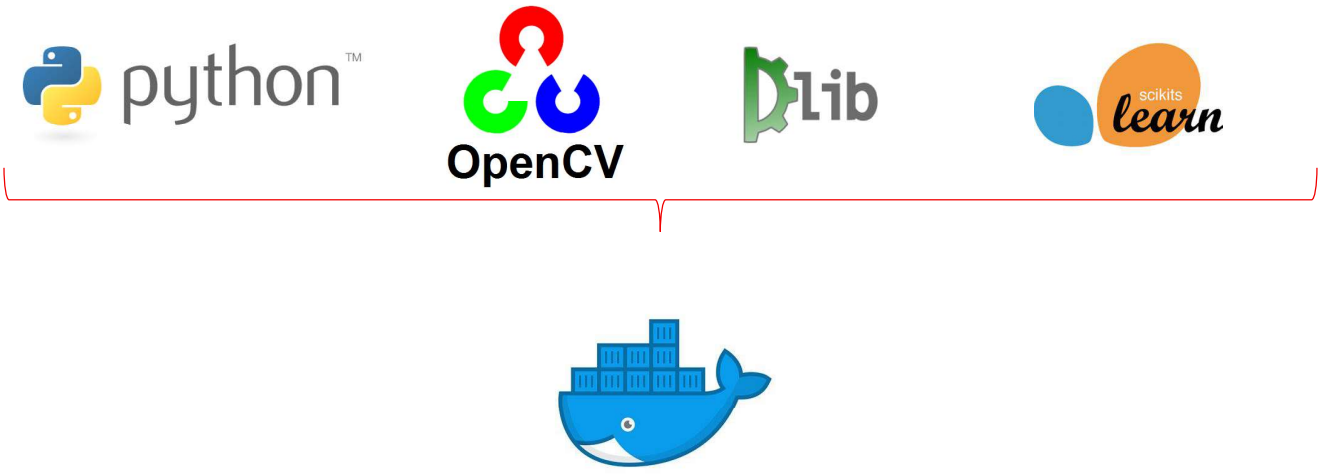
- Machine learning to detect facial landmarks
- Machine learning to detect face configuration and emotion
- Some code to overlay sprites on your face via your web cam



Open Mouth

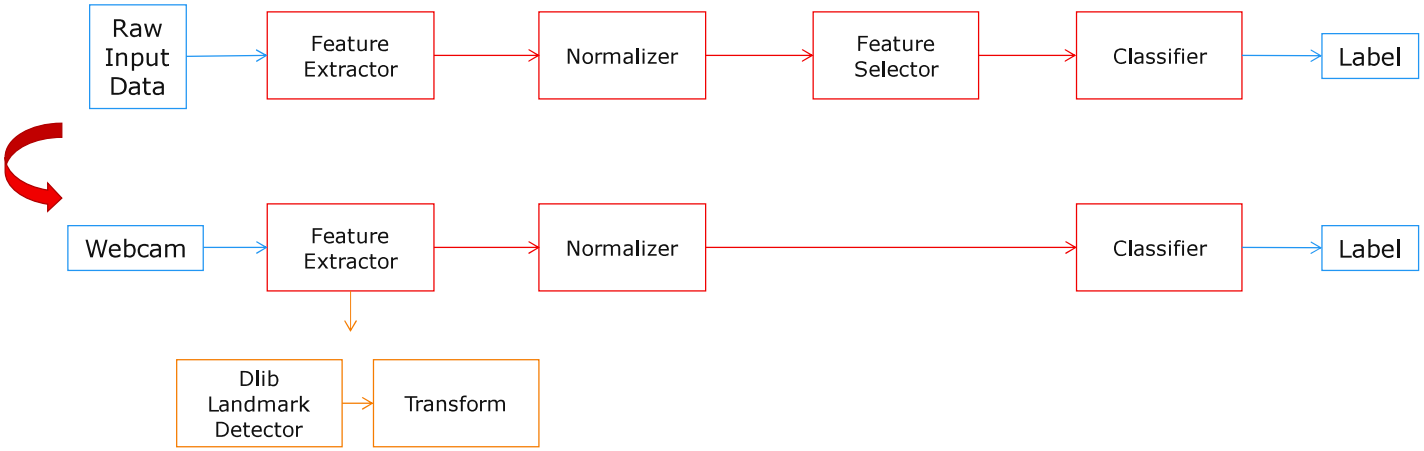
It is show time! … Again!

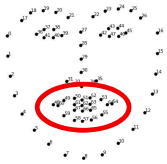
What will we use for this?



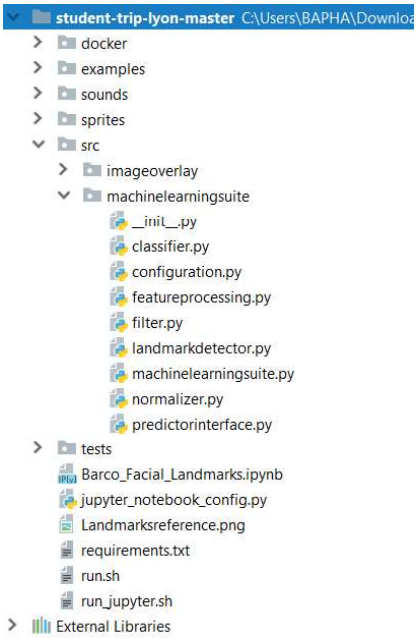
Hands-on – Introduction

Same pipeline as before

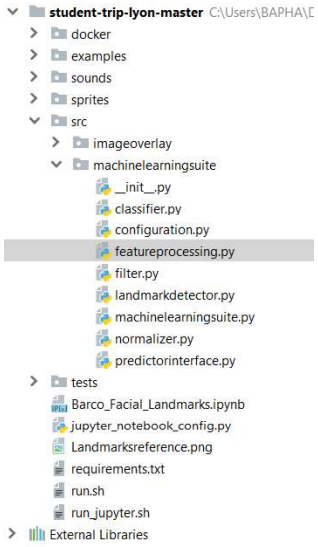




Hands-on – Material

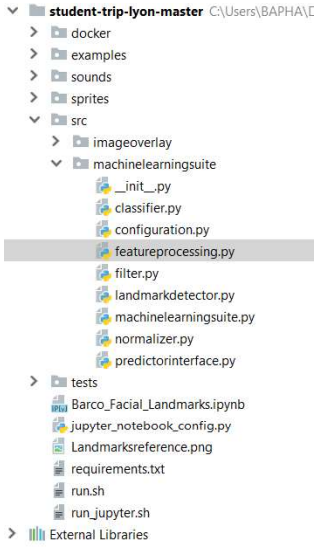


Hands-on – Material



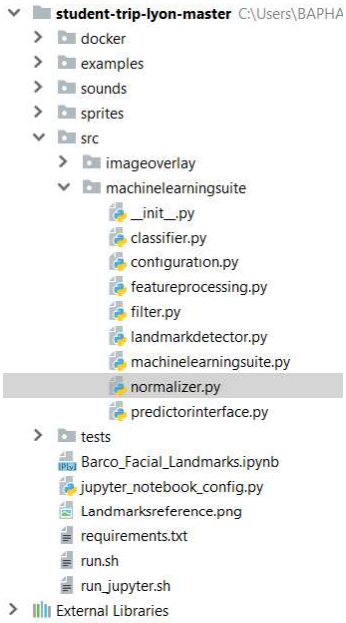

```python
class FeatureProcessing:

    def __init__(self, configuration):
        self.configuration = configuration
        self.parts = []
        self.markers = {
            "left-eyebrow": {
                "idx": list(range(17, 22)),
                "ref": 19
            },
            "right-eyebrow": {
                "idx": list(range(22, 27)),
                "ref": 24
            },
            "left-eye": {
                "idx": list(range(36, 42)),
                "ref": 41
            },
            "right-eye": {
                "idx": list(range(42, 48)),
                "ref": 46
            },
            "nose": {
                "idx": list(range(27, 36)),
                "ref": 30
            },
            "mouth": {
                "idx": list(range(48, 68)),
                "ref": 57
            },
            "jaw": {
                "idx": list(range(0, 17)),
                "ref": 8
            }
        }
```


Hands-on – Material



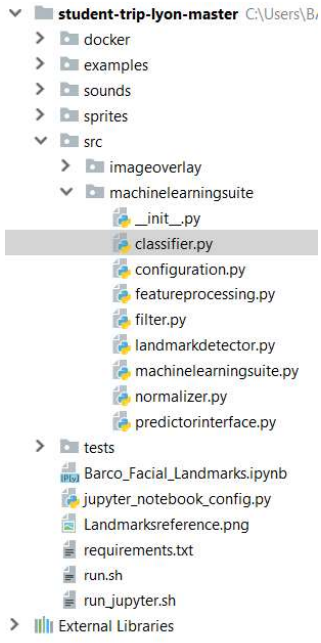

```python
def process(self, landmarks):
    if landmarks:
        if not len(landmarks[0]) == 68:
            return []
    else:
        return []

    for part in self.parts:
        if not part in self.markers:
            print("{} is not accepted as a face part".format(part))
            return []

    raw_feature_vector = []
    for part in self.parts:
        ref = self.markers[part]["ref"]
        markers = np.asarray(self.markers[part]["idx"])

        part_landmarks = [landmarks[0][i] for i in markers]
        ref_landmark = landmarks[0][ref]

        for landmark in part_landmarks:
            landmark_diff = np.subtract(landmark, ref_landmark)
            for element in landmark_diff:
                raw_feature_vector.append(element)
    return raw_feature_vector
```

Hands-on – Material



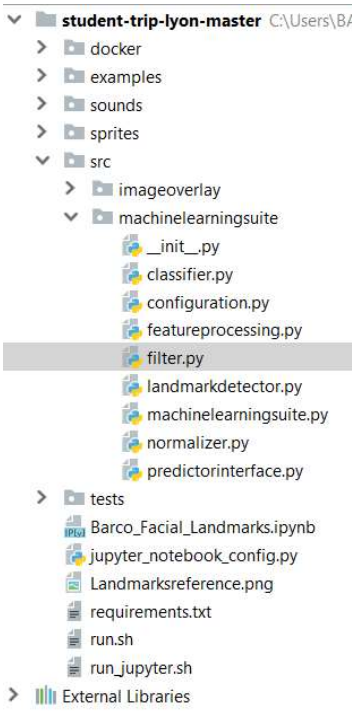

```python
class Normalizer:
    def __init__(self, configuration):
        self.configuration = configuration
        self.normalizer = preprocessing.Normalizer()

    def load_configuration(self):
        if self.configuration.normalizer:
            self.normalizer = self.configuration.normalizer

    def save_configuration(self):
        self.configuration.normalizer = self.normalizer

    def train(self):
        X = self.configuration.data_values
        self.normalizer.fit(X)
        self.configuration.data_values_normalized = self.normalizer.transform(X)
        self.save_configuration()

    def normalize(self, data):
        data_normalized = self.normalizer.transform(data)
        return data_normalized
```


Hands-on – Material



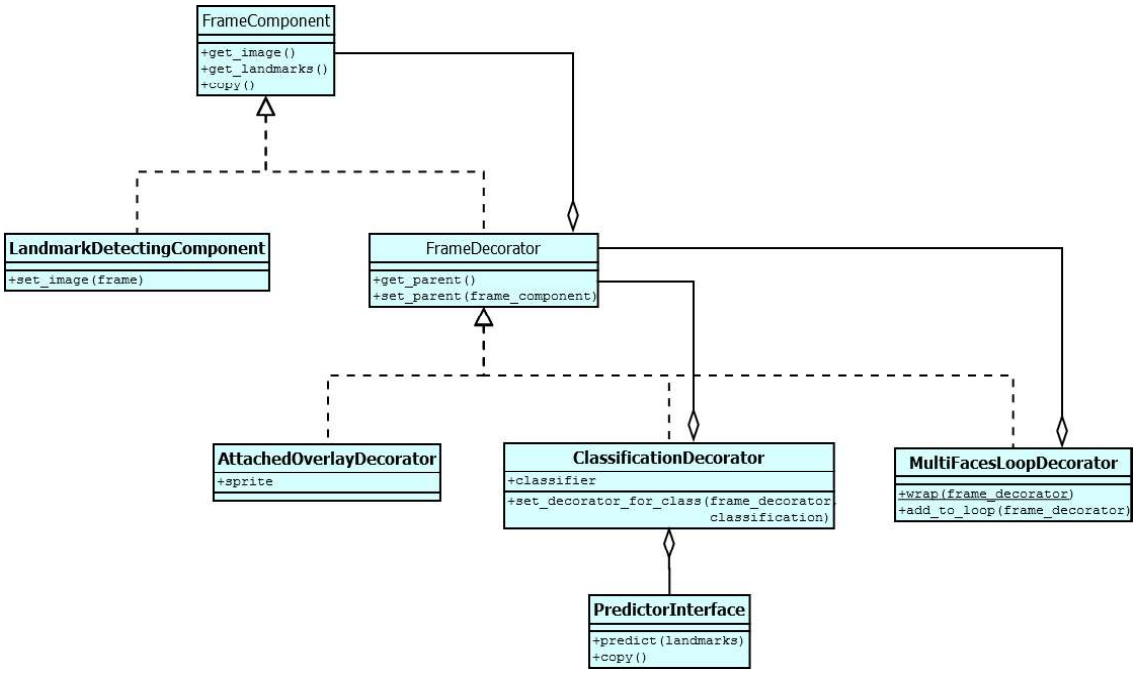

```python
class Classifier:
    def __init__(self, configuration):
        self.configuration = configuration
        self.classifier = svm.SVC(kernel='linear', C=1000)
        # self.classifier = svm.SVC()
        # self.classifier = svm.LinearSVC()
        # self.classifier = svm.SVC(decision_function_shape='ovo')

    def load_configuration(self):
        if self.configuration.classifier:
            self.classifier = self.configuration.classifier

    def save_configuration(self):
        self.configuration.classifier = self.classifier

    def train(self):
        X = self.configuration.data_values_normalized
        y = self.configuration.data_labels
        self.classifier.fit(X, y)
        self.save_configuration()

    def predict(self, data):
        return self.classifier.predict(data)
```

Hands-on – Material

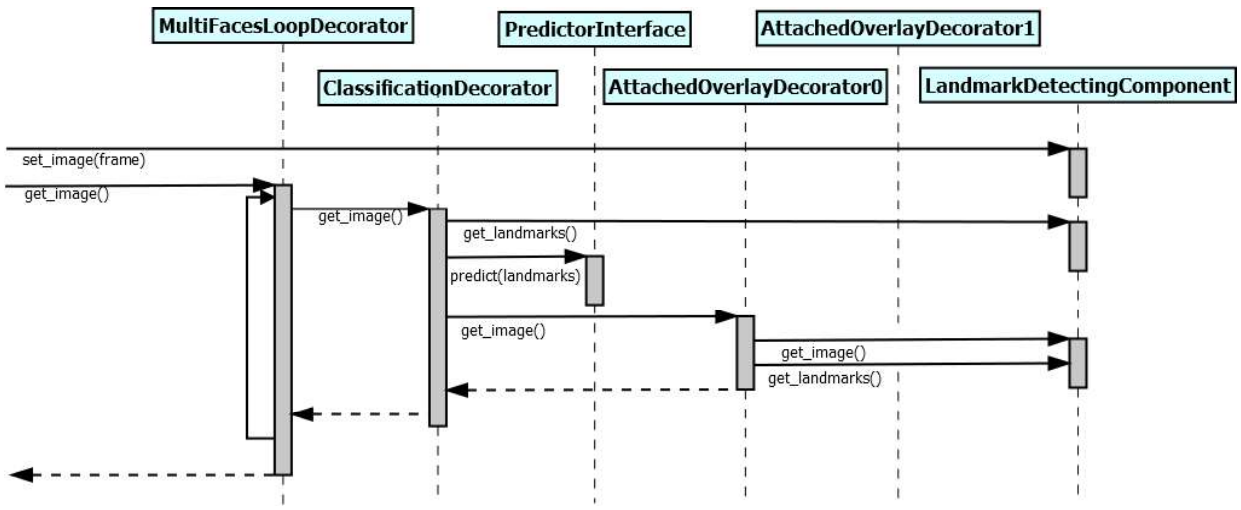



```python
class Filter:

    def __init__(self, queue_size):
        self.queue_size = queue_size
        self.queue = collections.deque(maxlen=queue_size)

    def filter(self, prediction):
        self.queue.append(prediction[0])
        if len(self.queue) == self.queue_size:
            queue = np.asarray(self.queue)
            return np.bincount(queue).argmax()
        else:
            return None
```


Hands-on – Material



Hands-on – Material



Hands-on – Material

```
    def predicting_example():
        # Instanciate a new landmark detector
        detector_data_path = '../../data/shape_predictor_68_face_landmarks.dat'
        landmark_detector = LandmarkDetector(predictor_file=detector_data_path)

        # Create a frame component with landmarks
        base_component = LandmarkComponent(landmark_detector)

        # Instantiate and initialize the trained predictor
        predictor = PredictorInterface('../examples/emotion.pkl')
        predictor.initialize()

        # Add decorator for the predictor
        predictor_decorator = ClassDecorator(parent_component=base_component, classifier=predictor)
        sunglasses = SpriteDecorator(base_file_name='../sprites/sunglasses')
        eyes = SpriteDecorator(base_file_name='../sprites/eyes')
        predictor_decorator.set_decorator_for_class(sunglasses, 0)
        predictor_decorator.set_decorator_for_class(eyes, 1)

        multifaces = AllFaces.wrap(predictor_decorator)
```

```
            base_component.set_image(frame)
            output = multifaces.get_image()
```

Hands-on – Get Started

- Get docker image from:
  docker pull bapha/student-trip-lyon
- Get source code from:
  git clone https://github.com/bhanssens/student-trip-lyon.git
- ./run.sh
- Start ‘pycharm’ or ‘jupyter notebook’
- Have a look in ./examples

Hands-on – Practice

1. Show facial landmarks
2. Add overlay
3. Train classifier: Open/Closed mouth
4. Link overlay to classifier
5. Go crazy!

Hands-on – Further Exercises

- Create a text overlay
- Face swap
- Draw a new sprite at run-time
- Create animations
- Program a (competitive) game (e.g. eating dots of the screen)
- Train a classifier for tilting your head in one or the other direction
- Create a nodding yes or no classifier
- Use the color of pixels to make a prediction (e.g. eye or hair color)
- Check out examples in dlib to label and train new object detectors and shape predictors

Final Note

Thanks for attending! Hope you enjoyed it!

The team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Research Engineer


Baptiste Hanssens
Research Engineer


Jonas De Vylder
Research Engineer


Samuel Dauwe
Research Engineer


You ?

- **User Experience**: 3D rendering frameworks, web technologies, human machine interaction,…
- **GPU**: high performance, low delay, high throughput image processing (from almost driver level till CUDA/OpenCL, VULKAN,…)
- **Security**: product risk assessments, ethical hacking,…

ENABLING BRIGHT OUTCOMES

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