Unsupervised Decomposition of Images into Motifs

Décomposition non supervisée d'images en sous-motifs

2022-06-16

Rémi EMONET

Atelier « Enjeux et méthodes d’analyse d’ornements anciens »

Disclaimer

Avertissement

Overview

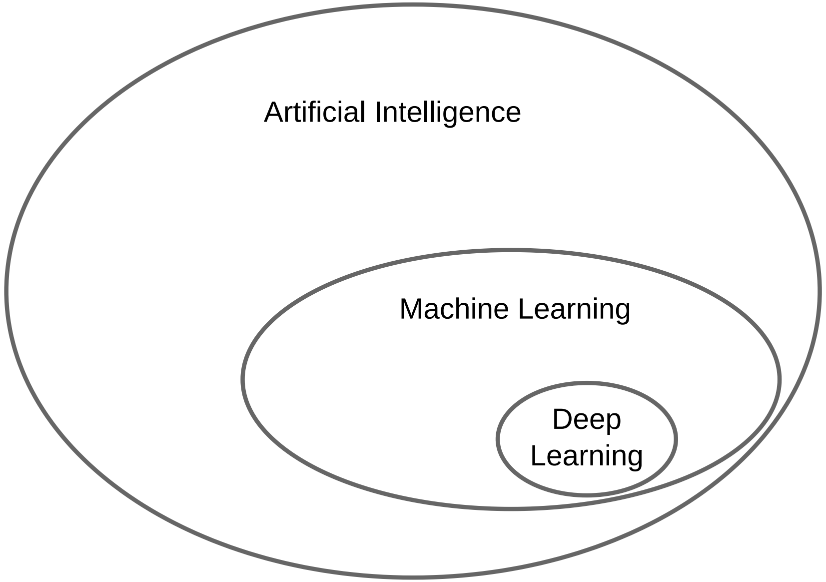
- Different Flavors of Machine Learning
- Why Looking for Sub-Motifs
- Decomposing Spatio-Temporal Data Using Probabilistic Models
- Towards "Modern" Approaches to Decomposition
- Summary and Conclusions

Different Flavors of Machine Learning

Le « Machine Learning » et ses multiples facettes

Artificial Intelligence / Machine Learning / Deep Learning

Intelligence Artificielle / Apprentissage Automatique / Apprentissage Machine



> Machine learning is a subset of artificial intelligence in the field of computer science that often uses statistical techniques to give computers the ability to "learn" (i.e., progressively improve performance on a specific task) with data, without being explicitly programmed. *wikipedia*

Software design and its limitation

Écriture de logiciels et ses limitations

- Traditional software
  - a developer write a program
    - i.e., a set of instructions that the computer understands
    - i.e., very elementary operations or more complex ones, writen beforehand
  - the instructions (should) solve the task of interest
    - given some input, the computer applies the instructions, a result is produced
- Limitations: the developer is not a domain expert, and vice versa
  - also, translating human knowledge/intuition into a program might be difficult
    - e.g., what does it mean to find a cat in a picture?
- Expert systems
  - encode expert knowledge in a database
  - write a (more) generic program that uses this database

Supervised Machine Learning

Apprentissage automatique supervisé

- Limitation of traditional and expert systems
  - reminder: write a program and/or expert knowledge
  - encoding expert knowledge is time consuming
  - choosing the proper knowledge representation is very difficult
  - formalizing the knowledge might be close to impossible
- *Supervised machine learning*: principle
  - use a *labeled dataset* with
    - some example inputs (e.g. images)
    - for each input, the associated expected output (label) (e.g. whether it is a cat or not)
    - just labels, no analysis of the expert knowledge
  - apply a (machine learning) algorithm/program, which
    - inputs the whole labeled dataset
    - outputs a *model* that can automatically affect a label to a new input (a model ≈ a program)

Supervised Machine Learning, creating a dataset


, Cat


, Cat


, NonCat


, Cat


, NonCat


, NonCat

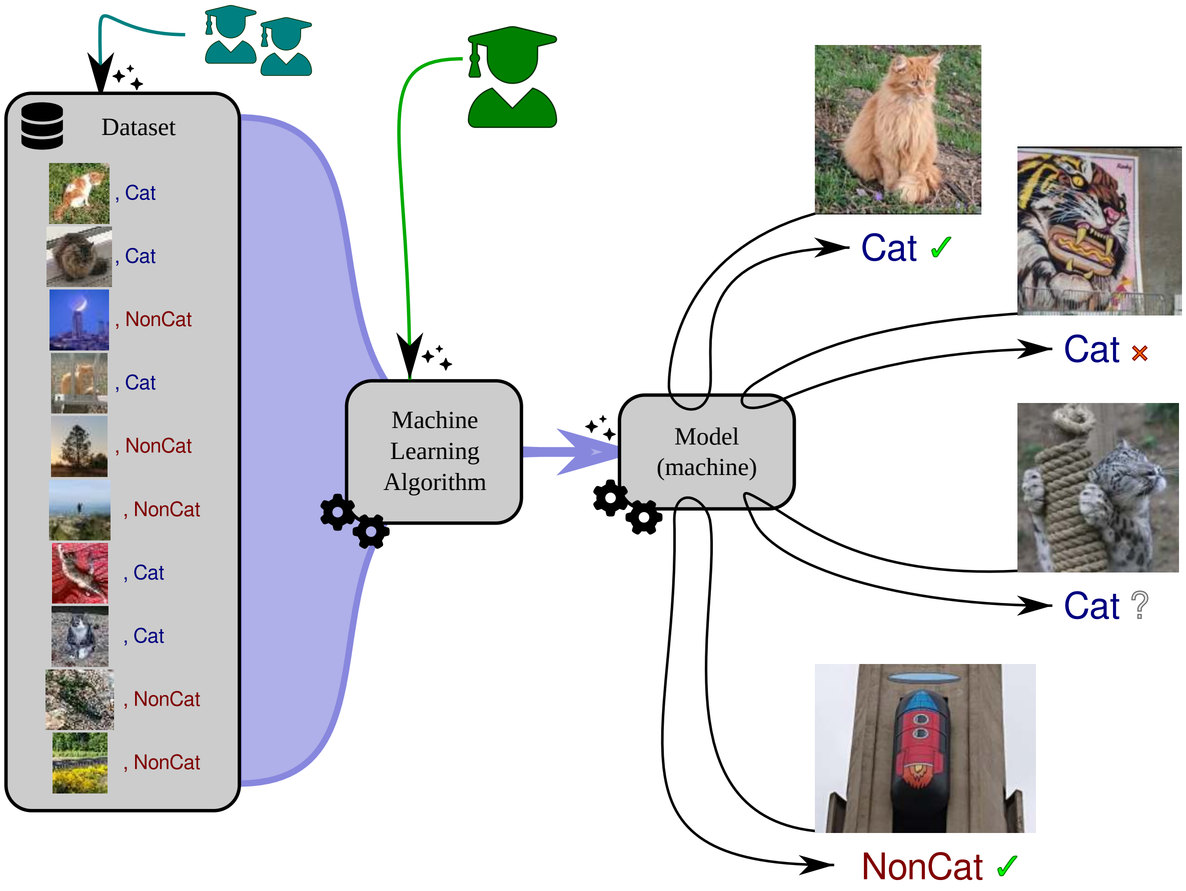

, Cat


, Cat


, NonCat


, NonCat

Supervised Machine Learning, illustrated

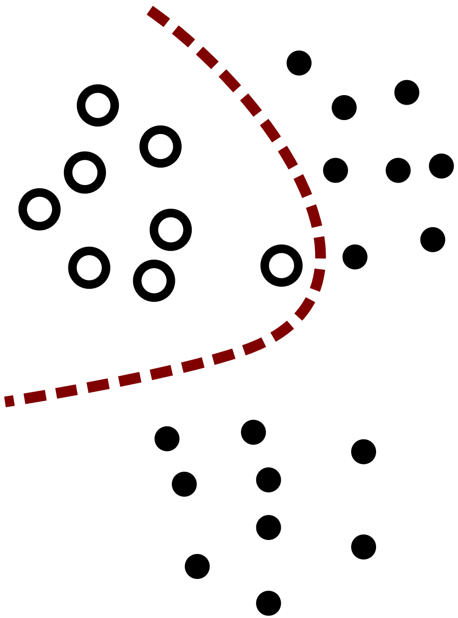


Many Applications of Supervised Learning

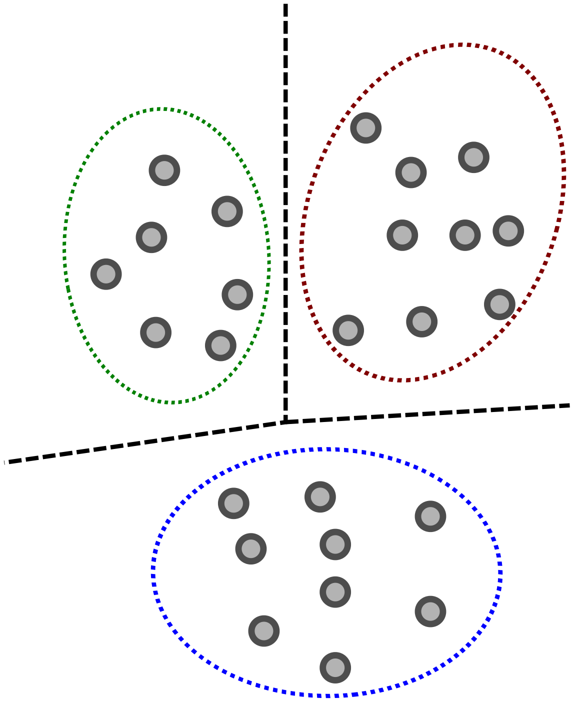
- Image classification and search,
- Automated translation,
- Spam detection,
- …
- Text/Banner/Ornament segmentation (pixel classification)
- Localization of (known) vignettes (bounding box detection)

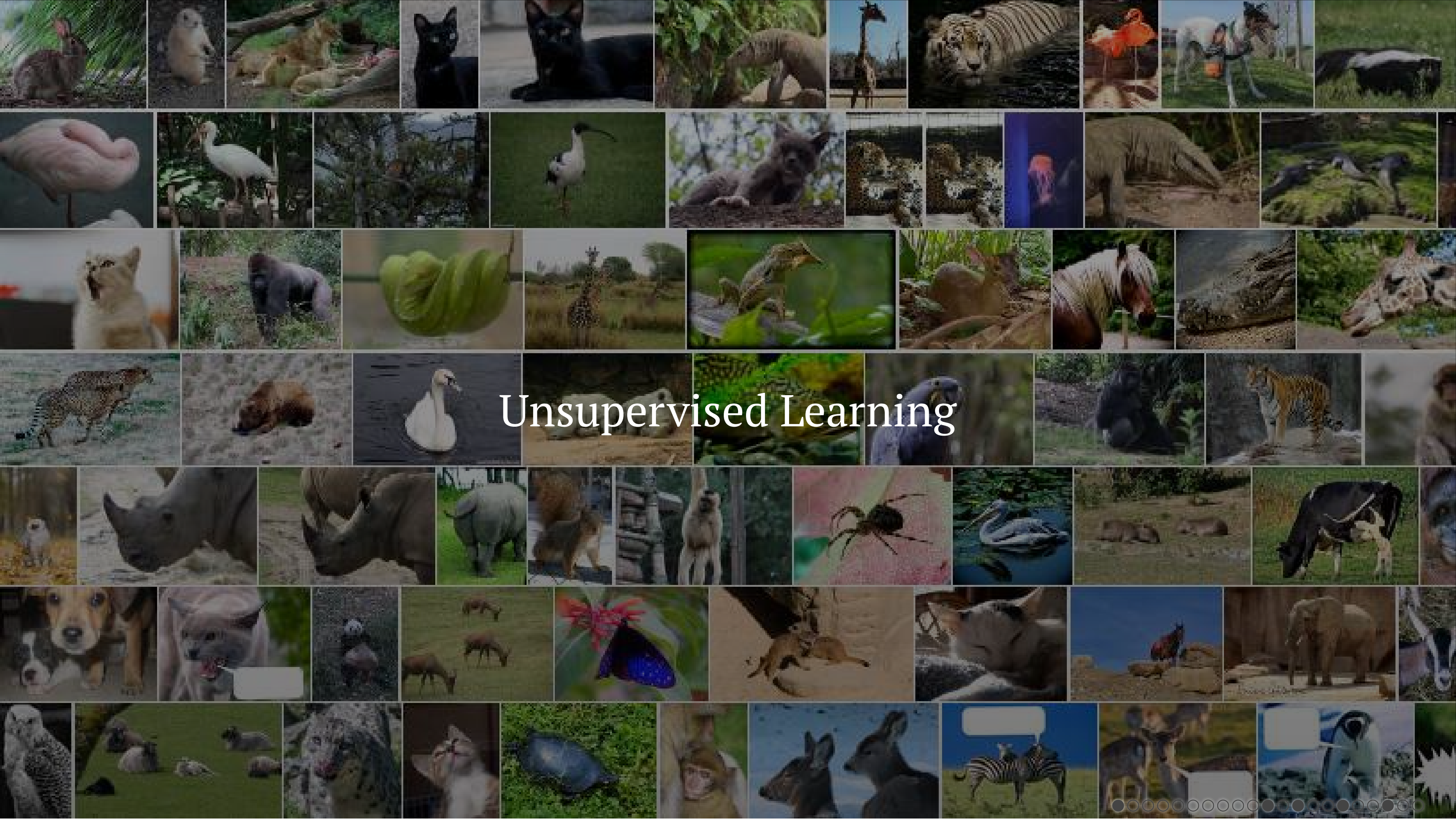
Supervised vs Unsupervised |||| ex: Classification vs Clustering

Supervised
(known labels)



Unsupervised
(only inputs)





Unsupervised Learning

Other Machine Learning Setups

- supervised
- semi-supervised
- weakly supervised
- self supervised
- active learning
- reinforcement learning

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Why Looking for Sub-Motifs

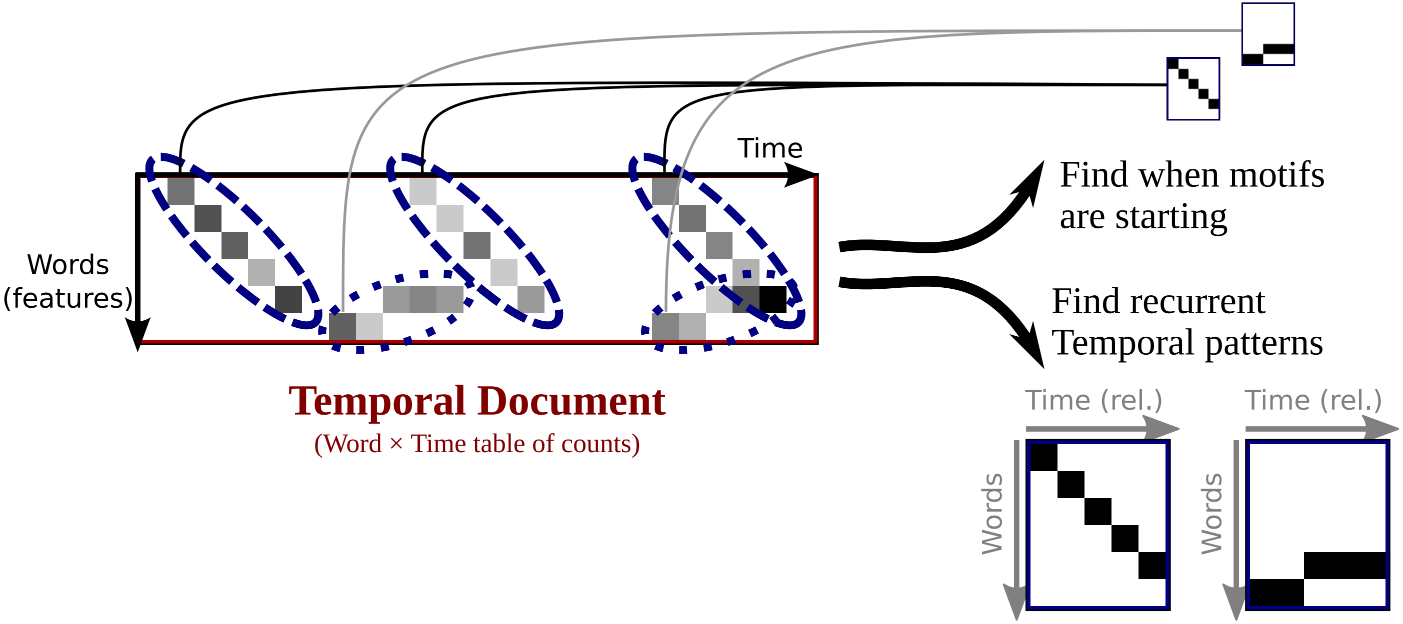
Pourquoi de la Recherche de (sous-)motifs

Motivation

Decomposing Spatio-Temporal Data Using Probabilistic Models

Décomposition de données spatio-temporelles avec des modèles probabilistes

Finding Temporal Motifs
in videos / temporal data (spectrograms, ...)



Temporal Document

(Word × Time table of counts)

Motifs

(Word × Relative-time tables)

Principle of Probabilistic Modeling (generative models)

Modèles Probabilistes Génératifs

- Generative story
  - assumptions
  - expert intuition
  - may be difficult
- Challenges
  - encode knowledge as structure
  - derive/write the optimization algorithm
  - … jointly

Towards "Modern" Approaches to Decomposition

Vers les Approches Modernes de Décomposition

Deep Learning Approaches to Decomposition

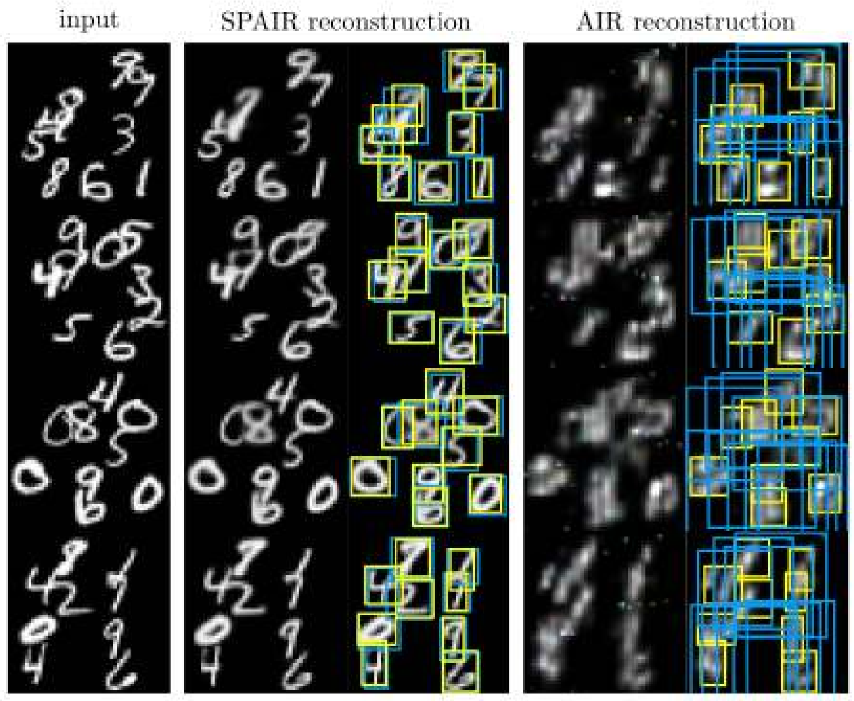
Apprentissage Profond pour la Décomposition

- Use "Deep Learning" approaches
  - gives more flexibility when encoding knowledge as structure
  - directly reuse the optimization algorithm
  - but, usually require more data

Some recent approaches

Quelques nom d'approches récentes

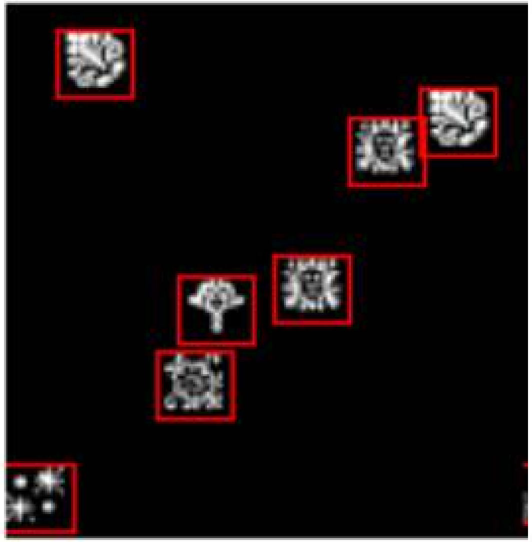
- AIR (2016), SPAIR (2018)
- IODINE, GENESIS
- DAIR, SQAIR, R-SQAIR
- SPACE
- RICH (~~2020~~)
- …

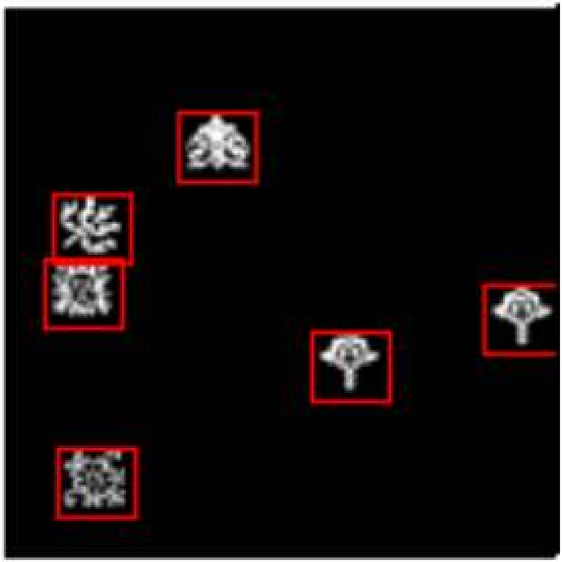


First Explorations with Ornaments

Making a Fake Dataset of Composed Ornaments

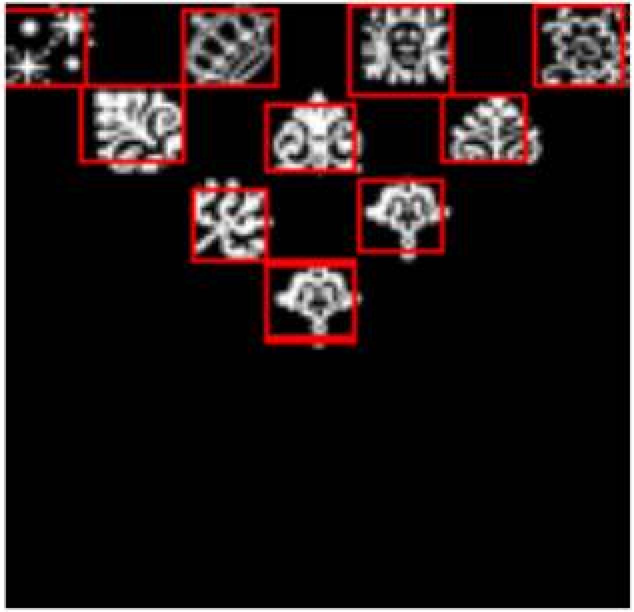
- Using some manually extracted "vignettes"
- Generate many images with several vignettes
- Labels available for free (used just for evaluation)

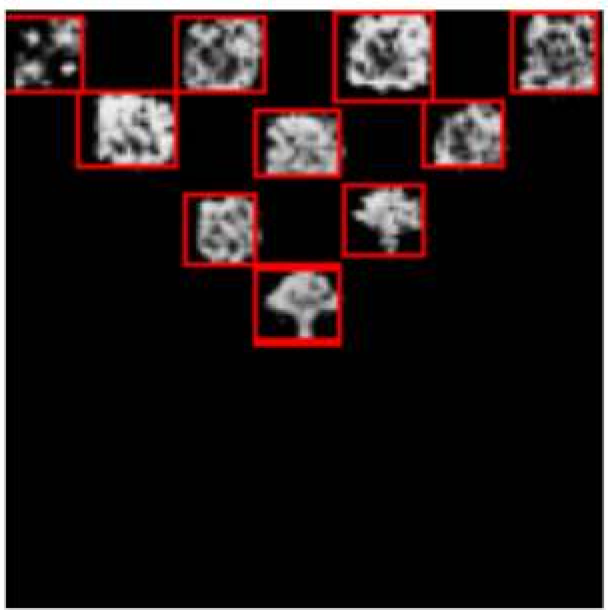




Some Results: on an image with similar vignettes

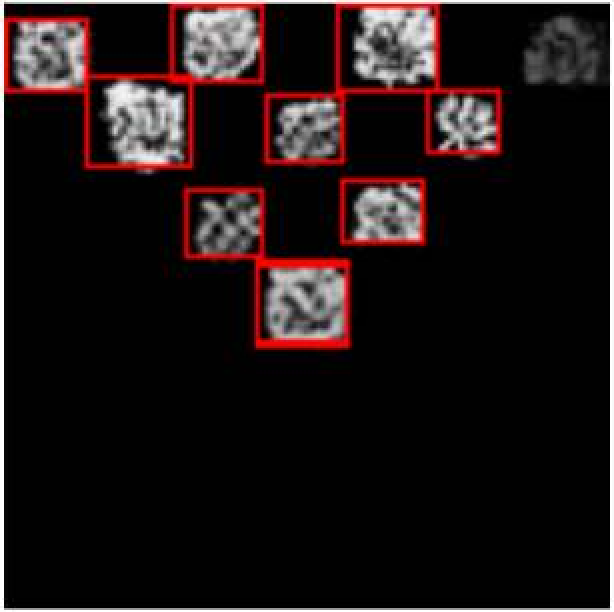
Résultat: exemple sur une images avec des vignettes similaires





Some Results: on an image with unseen vignettes

Résultat: exemple sur une images avec des vignettes nouvelles



Possible Outcomes

Résults (futurs) éventuellement possibles

- To be expected
  - decomposing unlabeled datasets of composite ornaments
  - grouping (and showing) similar vignettes
  - highlighting differences,
  - suggest hierarchical aggregations of vignettes
- Open questions
  - decomposing "passe-partout"
  - integrating/inferring metadata
    - print date, official address, official printer,
    - … and actual ones
    - "alphabet" available at given workshop
  - inferring/integrating "latent" information
    - vignette rotation (90°, 180°)
    - aging of woods/vignettes
    - pressing style or intensity, inking
  - learning the composition style (need more data?)

Summary and Conclusions

Take-Home Message

- Machine Learning uses data to automatically write programs
- Supervised Learning is amazing and is used a lot
- Unsupervised Learning is challenging but also amazing
- Decomposing images in recurrent motifs might be useful for composite ornaments