

Machine-Learning-Artificial-Intelligence Meetup Bern

Graph-based Pattern Recognition – Example Application Keyword Spotting

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$c_{21}$	$c_{22}$	$\dots$	$c_{2m}$	$\infty$	$c_{2\varepsilon}$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\vdots$
$\vdots$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\vdots$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\infty$
$c_{n1}$	$c_{n2}$	$\dots$	$c_{nm}$	$\infty$	$\dots$	$\infty$	$c_{n\varepsilon}$
$c_{11}$	$\infty$	$\dots$	$\infty$	$0$	$0$	$\dots$	$0$
$0$	$c_{\varepsilon 2}$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\vdots$	$0$	$0$	$\begin{smallmatrix} \cdot \\ \cdot \\ \cdot \end{smallmatrix}$	$\vdots$
$\vdots$	$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$	

## Content

- What is Pattern Recognition (PR) ?
- Statistical vs. Structural PR
- Graph-based Keyword Spotting
- Conclusion
- Q+A

## What is Pattern Recognition (PR)?

PR deals with the **recognition** of **patterns** and the correct **anticipation** of **actions**.




**Pattern** (Video, Image, DNA, etc.)

**Action** (Classification, Clustering, etc.)

## Statistical vs. Structural PR

Sequence of Feature Vectors

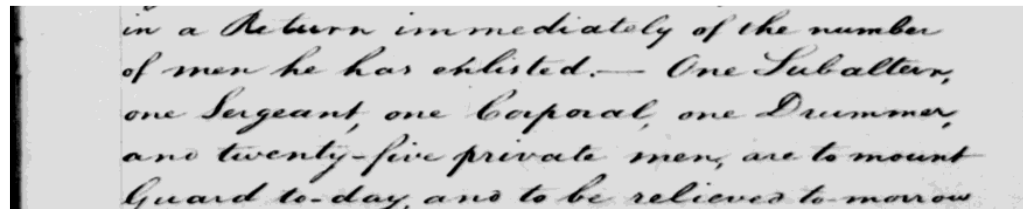
Strings, Trees, or Graphs


$$w = \{x_1, \dots, x_n\}$$

- + Efficiency
- Representational Power

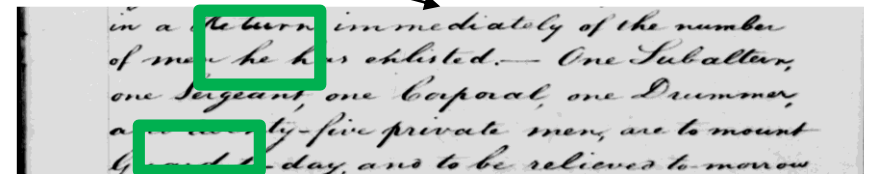
- Efficiency
- + Representational Power

## Transcription vs. Keyword Spotting in Handwritten Historical Documents



Query: Orders

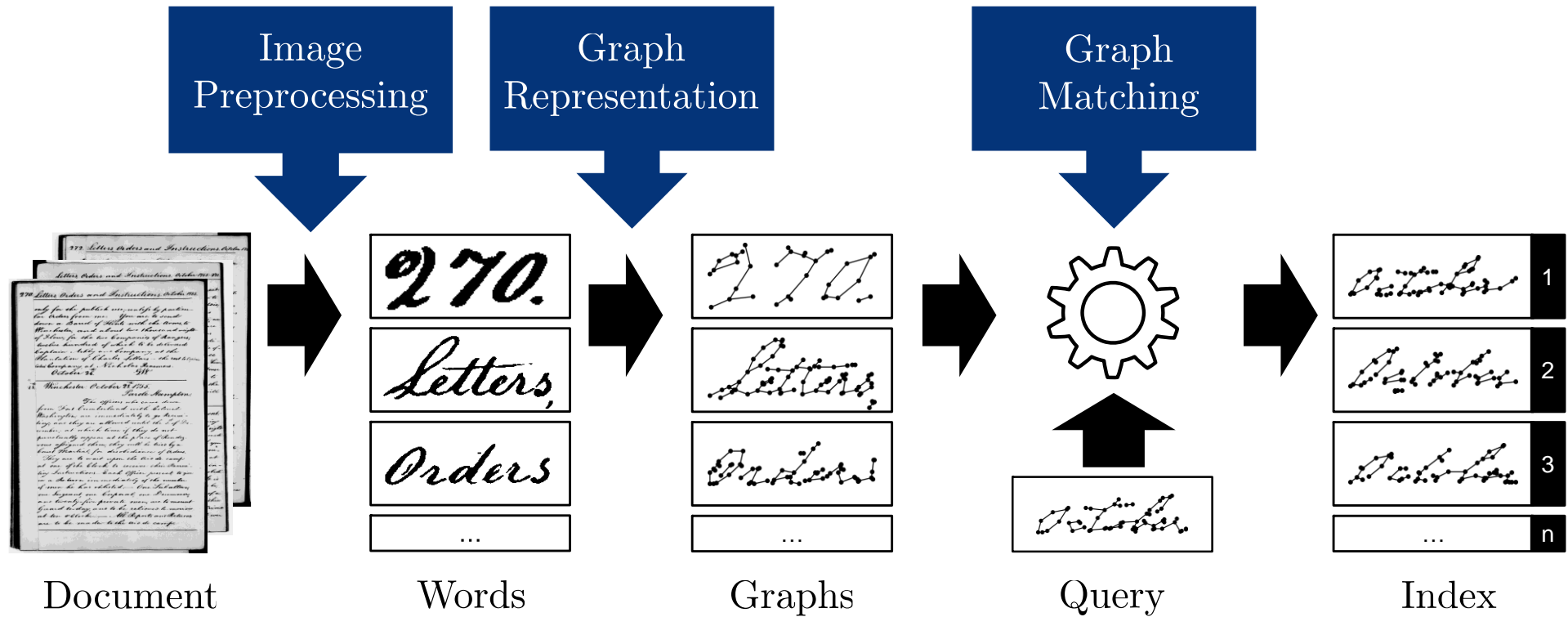
270. Letters, Orders and Instructions. October 1755.  
only for the publick use-unless by particular Orders from me. You are to send



++ Accessibility  
- Applicability

+ Accessibility  
++ Applicability

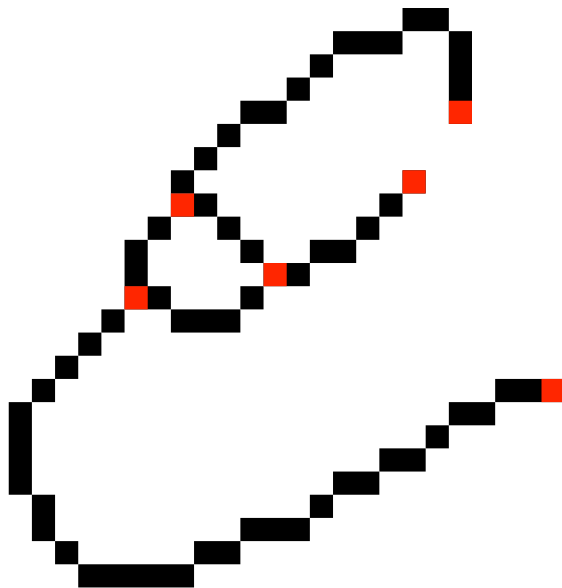
## Graph-based Keyword Spotting



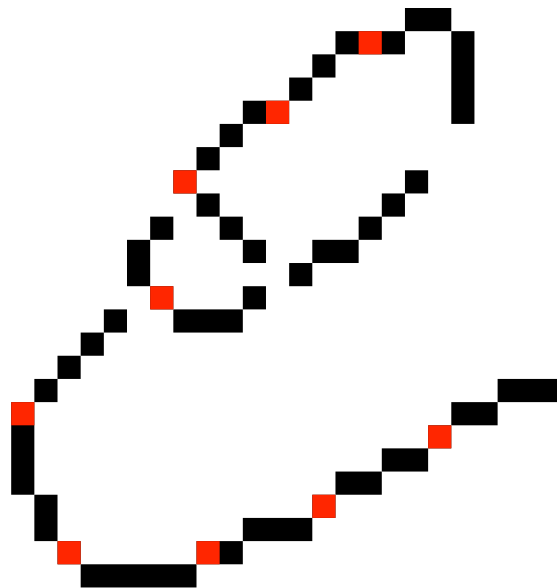
## Graph-based Keyword Spotting – Keypoint Graph Representation

**Input** Skeletonised Word Image

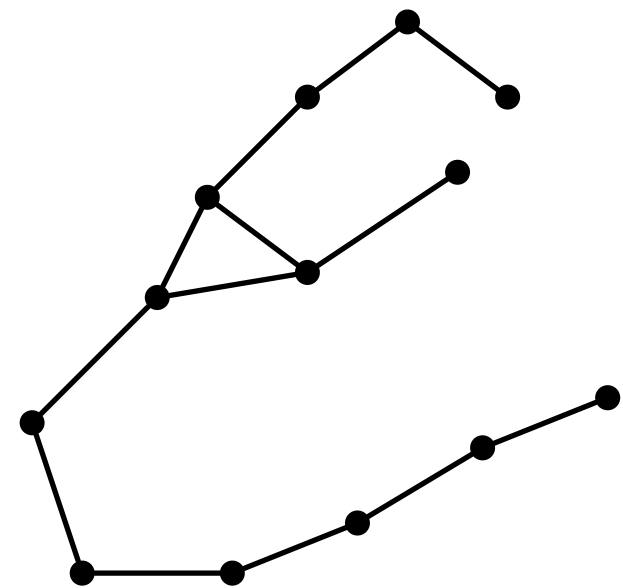
**Output** Graph



1. Keypoints



2. Intermediate  
Points

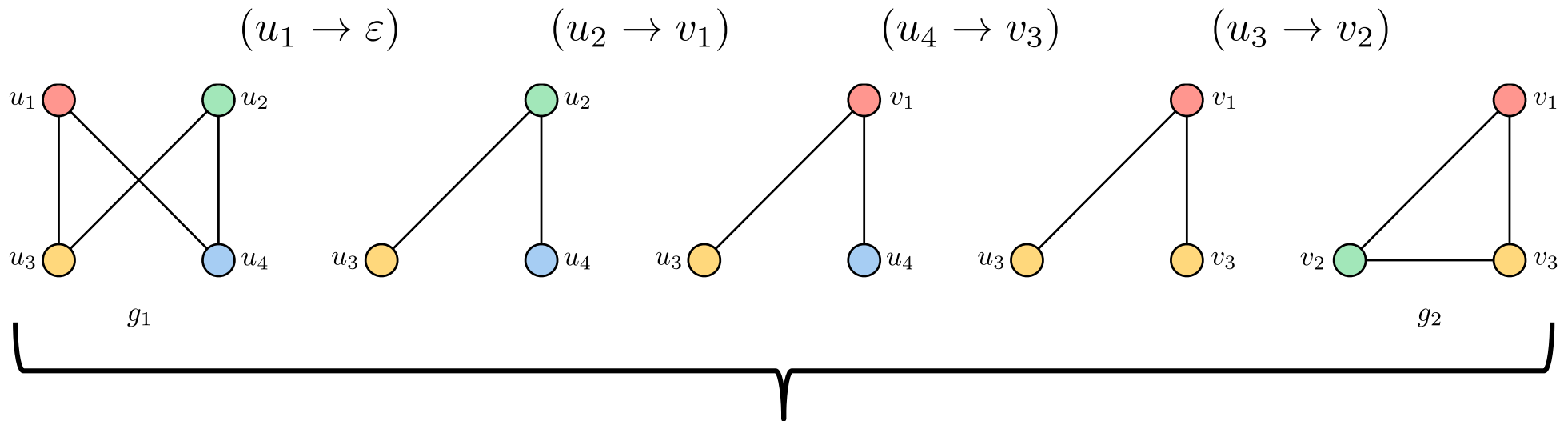


3. Graph

## Graph-based Keyword Spotting – Graph Edit Distance (GED)

GED = Minimum amount/cost of distortion to transform graph  $g_1$  into graph  $g_2$

*Edit path*



Number of edit paths is exponential > We need approximative approaches



## Conclusion

- Graphs offer a natural way of representation
  - Molecules
  - Social Networks
  - Handwriting
  - etc.
- Graph-based Keyword Spotting
  - Makes handwritten historical documents accessible
  - Can keep up with Deep Learning (Convolutional Neural Networks)
  - No labelling needed
- Future Trends
  - Deep Learning for Graphs

**Q+A**

**? !**