ZRK Zintegrowany Rejestr Kwalifikacji

Testing approaches to automatic comparison of qualifications in Poland – initial results

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Integrated Qualificaton Register

✓over 10 000 qualifications (10 001 – November 28, 2019)

✓ca. 700 contain full descriptions of LO's

✓ca. 500 contain short descriptions of LO's

By the end of the year:

✓several dozens of new market qualifications (over 200 in queue for next year)

✓ca. 5000 descriptions for HE qualifications

✓ca. 215 descriptions for VET qualifications (new curriculum)

Our Context: Qualifications Register modernization

- ✓Improving searching and browsing usability
  (semantic search, filtering options, categorization and/or tagging of content, context browsing tools)
- ✓Developing automatic reporting and additional queries
  (qualifications comparison, generating lists of qualifications based on selected criteria, e.g. containing phrases, simliar to)
- ✓Designing web applications:
  - ✓„Compass”;
  - ✓„Learning pathways”;
  - ✓„Virtual assistant”.

The „WHY?”: Similar challenges to international context?

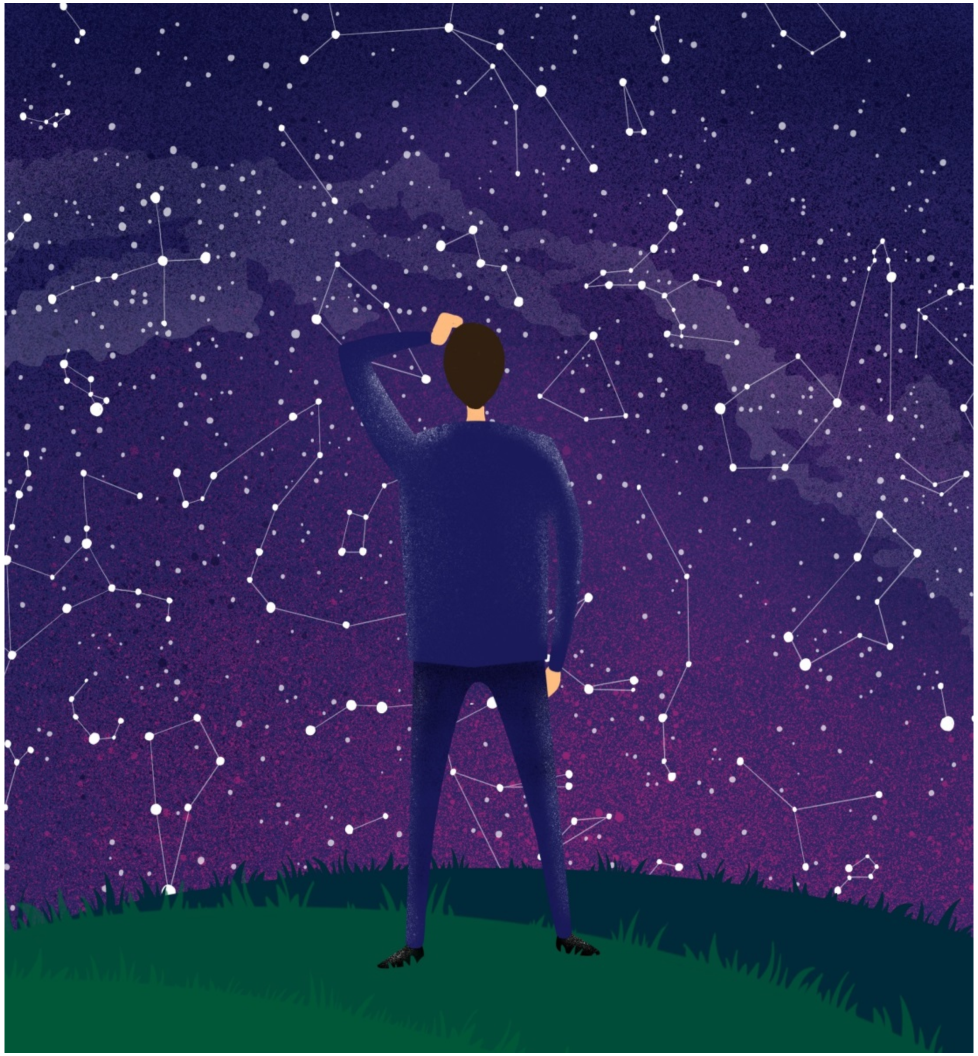
Policy perspectives:

✓ Accessibility and transparency of qualifications system;

✓ Credit accumulation and transfer and builiding learning pathways (awarding bodies and learners);

✓ Preventing proliferation of similar qualifications;

✓ …



The „WHAT?”: long list

- ✓Assessing similarity of objects;
- ✓Determining and representing relations between qualifications;
- ✓Grouping / clustering of qualifications;
- ✓Classifying and linking to existing taxonomies/classifications;
- ✓Supporting decision process and qualification design/description;
- ✓Supporting levelling proces.

The „HOW?”: A intuitive typology of approaches (for the purpose of this presentation only)

Analytical approaches:

- Based on separation of constitutent elements of a complex entity (e.g. key features identification);
- More formalised methodology and analysis process;
- Conceivable output

Holistic approaches:

- Based on analysis of whole entities;
- Exploiting the combination of vast (yet often undefined) knowledge and heuristic reasoning;

The „HOW?”: Similar challenges?

How many people do we need to compare, group, tag **10 000** qualifications of different structure and content?

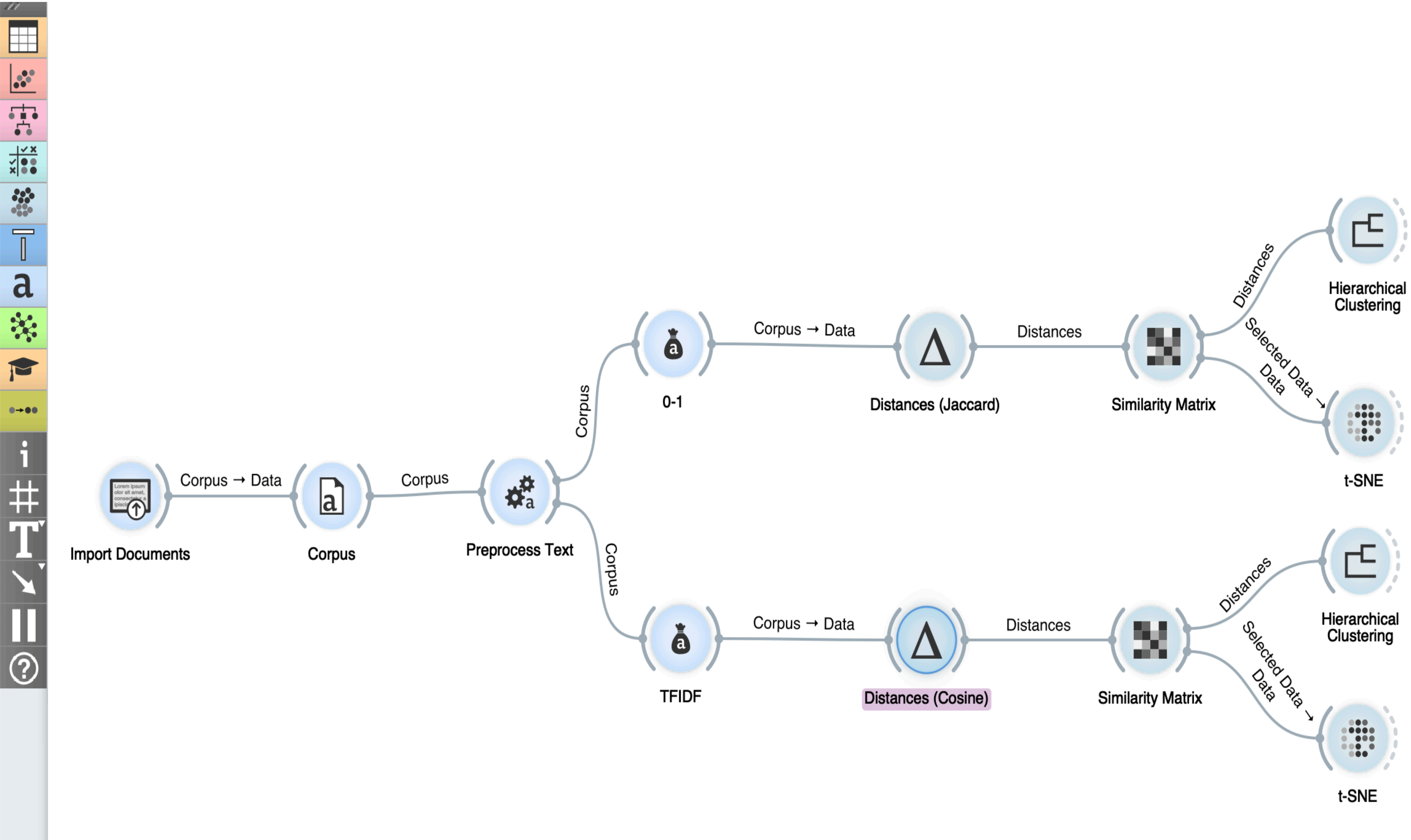
$$(X + Y) \times N$$

✓X analytics

✓Y qualifications experts

✓for N months

Exemplary pipelines in Orange



Two baseline approaches

	Approach no. 1	Approach no. 2
Basis for comparison	Learning outcomes	Synthetic description
Features	lemmatized nouns	lemmatized n-grams
No. of features	ca. 3300	ca. 4000
Feature weighting	0–1	TFIDF
Measure of similarity	jaccard	cosine

Natural Language Processing – basic terms

- ✓ lemmatization (detrmining base forms of words)
- ✓ jaccard index (of similarity)
- ✓ TFIDF
- ✓ n-grams
- ✓ cosine similarity

Example of data preprocessing: ’Atomization’ of learning outcomes (LO) – difficult task for Polish

Using NLP tools, we atomized the LO’s and extracted and lemmatized relevant words:

- (The learner) **describes** and **explains** the construction of **hammers** and **nails**

➔

- **Describes** the construction of the **hammer** +
  Explains the construction of the **hammer** +
  Describes the construction of the **nails** +
  Explains the construction of the **nails**

➔

- (**describe**, **hammer**, **explain**, **nail**, construction)

Jaccard index

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} = \frac{|A \cap B|}{|A| + |B| - |A \cap B|}$$

TFIDF

$$tfidf_{i,j} = \frac{n_{i,j}}{\sum_k n_{k,j}} \cdot \log \frac{|D|}{|d : t_i \in d|}$$

cosine similarity

$$\cos(\theta) = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\| \|\mathbf{B}\|} = \frac{\sum\limits_{i=1}^{n} A_i B_i}{\sqrt{\sum\limits_{i=1}^{n} A_i^2} \sqrt{\sum\limits_{i=1}^{n} B_i^2}}$$

… but let us focus on the results

Case 1. Dental assistant qualification: automated extraction of keywords

Key phrases (with TFIDF values):

0.181 lekarz dentysta [dentist]

0.181 dentysta [dentist]

0.176 stomatologiczny [dental]

0.161 dentystyczny [dental]

0.152 gabinet dentystyczny [dental surgery - place]

0.150 gabinet [surgery - place]

Case 1. Dental assistant qualification: most similar qualifications based on calculation of cosine similarity

The most similar qualifications (with cosine similarity):

0.9158 – Dental hygienist

0.7508 – Assisting the dentist and keeping the surgery ready for work

0.7347 – Paramedic

0.6841 – Orthoptist

0.6777 – Dental technician

Case 2. Design of websites qualification: automated extraction of keywords

Key phrases (with TFIDF values):

0.421 server

0.386 (to) create

0.268 client

0.231 content

0.216 database

0.212 copy

Case 2. Design of websites qualification: most similar qualifications based on calculation of cosine similarity

The most similar qualifications (with cosine similarity):

0.4638 – Programming, creation and administration of websites and databases (since September 1, 2017)

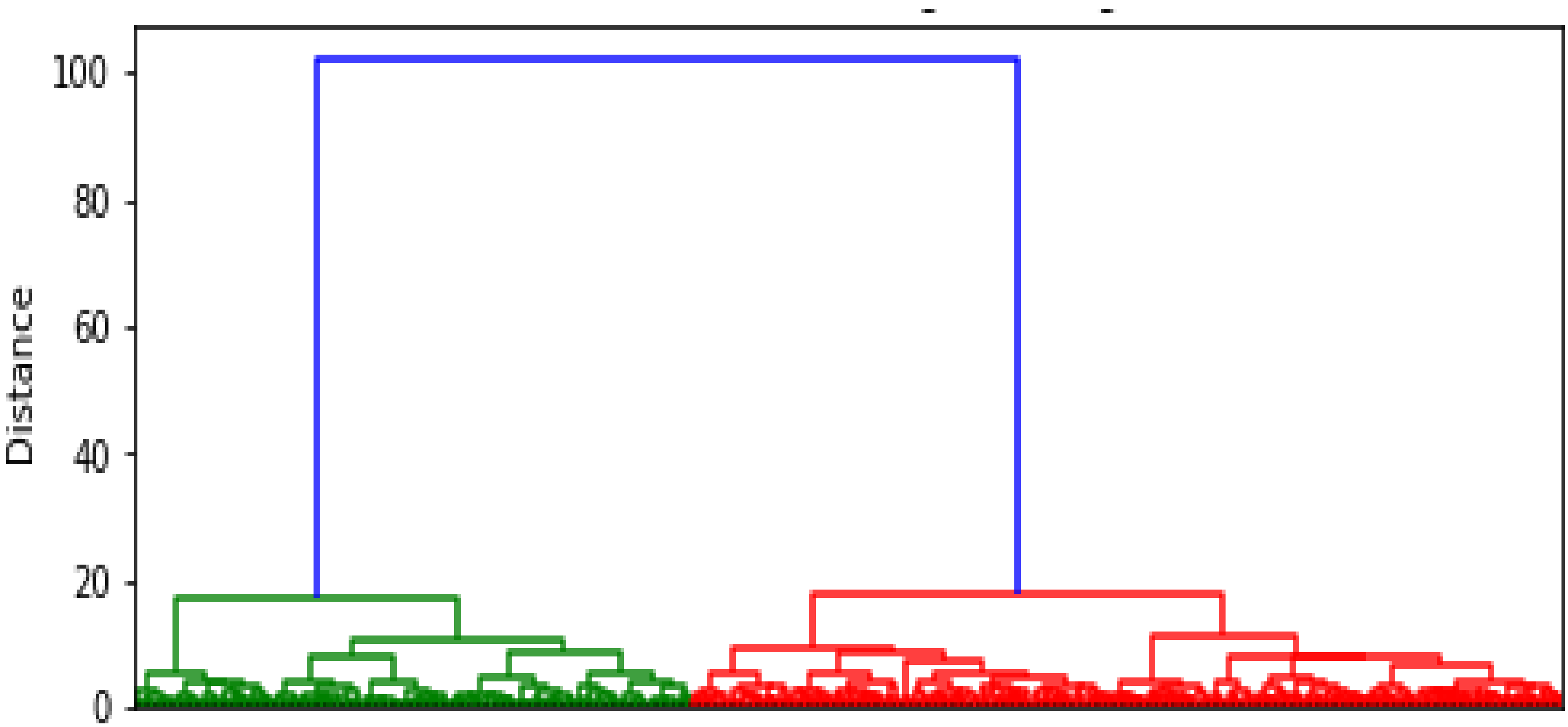
0.3346 – Creation of web applications and databases and administration of databases

0.2705 – IT technician (since September 1, 2017)

0.2223 – IT technician

0.2116 – Project management

Case 3. Deglomerative (top-down) hierarchical clustering dendrogram



Case 3. Deglomerative (top-down) hierarchical clustering dendrogram – example of 4th level cluster

- ✓ Exploitation of mechatronic systems in agriculture
- ✓ Exploitation of mechatronic systems in agriculture (since September 1, 2017)
- ✓ Use of vehicles, machinery, equipment and tools used in agriculture
- ✓ Maintenance and repair of vehicles, machinery and equipment used in agriculture
- ✓ Maintenance and repair of vehicles, machinery and equipment used in agriculture (since 1 September 2017)
- ✓ Beekeeping
- ✓ Conducting agricultural production
- ✓ Running an agritourism farm
- ✓ Organisation and supervision of agricultural and beekeeping production
- ✓ Organisation and supervision of agricultural production
- ✓ Animal husbandry, breeding and insemination
- ✓ Animal husbandry and insemination (since 1 September 2017)
- ✓ Performing auxiliary activities in the field of veterinary services
- ✓ Performing auxiliary activities in the scope of veterinary inspection tasks
- ✓ Performing auxiliary activities in the field of veterinary services and veterinary control and supervision (since September 1, 2017)

Case 3. Deglomerative (top-down) hierarchical clustering dendrogram – example of 6th level cluster with human labelling

- ✓ Exploitation of mechatronic systems in agriculture
- ✓ Exploitation of mechatronic systems in agriculture (since Septem
- ✓ Use of vehicles, machinery, equipment and tools used in agricult
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Machatronic systems in agriculture

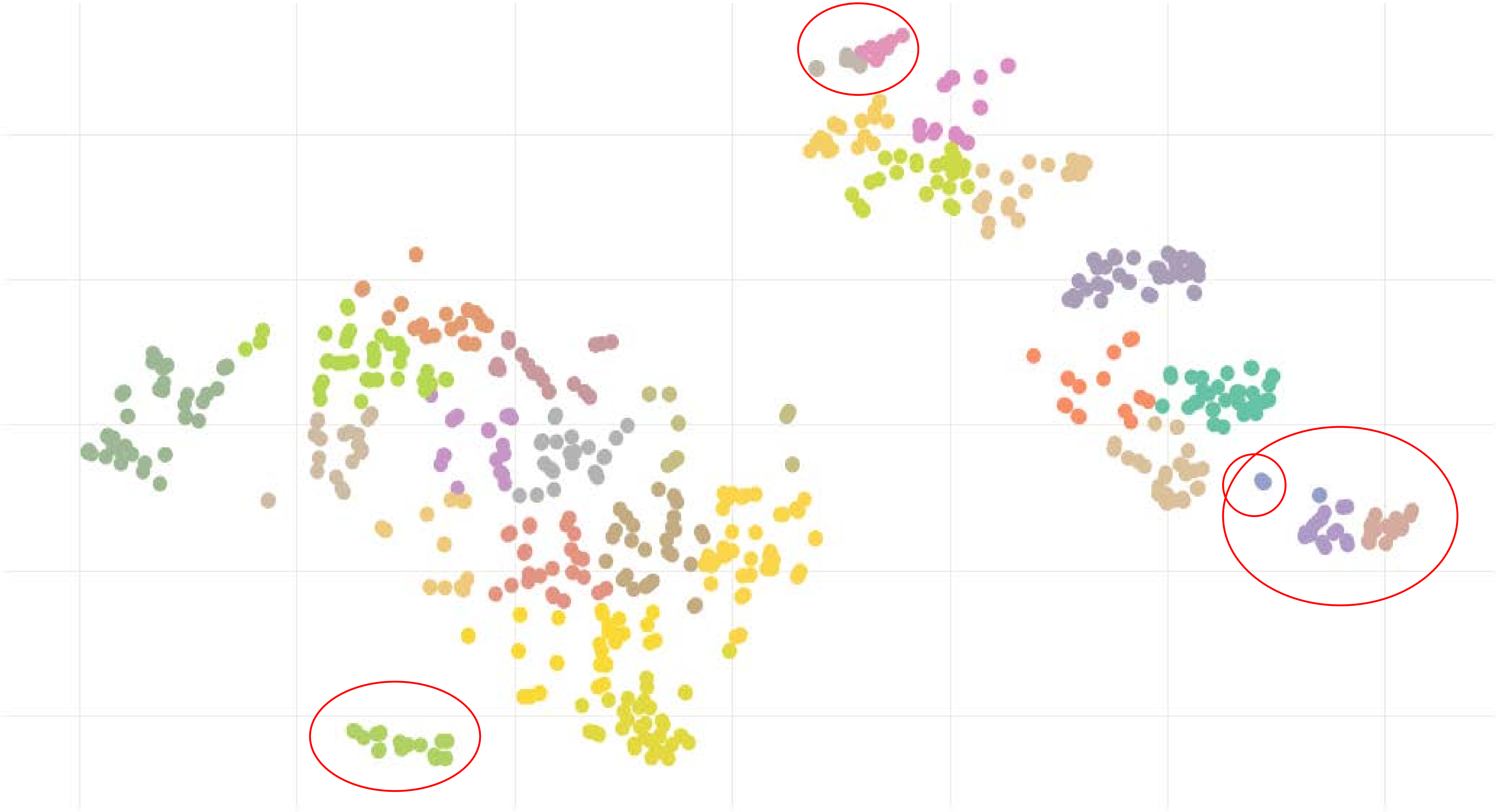
Vehicles maintenance

Agricultural production and beekeeping

Animal husbandry

Veterinary services

Case 4. T-SNE visualisation in 2D space with K-Means clustering (colours) (demo)



https://lbedk.shinyapps.io/t-sne/

We see our results as proof of concept for:

✓automated comparison of qualifications and explicable/interpretable degree of similarity

✓automated extraction of key phrases for qualifications

✓grouping / clustering of qualifications – independent from existing classifications

Work in progress

- ✓grouping methods pilotage and application – testing other approaches
    - ✓knowledge-based measures using WordNet
    - ✓vector language models (word2vec, fasttext, ELMo, USE…)
    - ✓ARTM (topic modeling)
    - ✓model ensembling
- ✓collecting data concerning occupations, job offers, etc. for the purpose of model training and data augmentation
- ✓consultations with experts, evaluation of results
- ✓feasibility study on chatbot
- ✓three applications supporting register users

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Thank You!

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