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The 4th International Conference on Artificial Intelligence in Education Technology (AIET 2023)

DARRAGH CARROLL & TIM SCHLIPPE

CONNECTING LEARNING MATERIAL AND THE DEMAND OF THE JOB MARKET USING ARTIFICIAL INTELLIGENCE

Berlin, Germany

July 2, 2023

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MOTIVATION

THE GAP BETWEEN EDUCATION AND THE JOB MARKET

- More rapid change in the job market than in education (Raffay-Danyi et al., 2022).

THE GAP BETWEEN EDUCATION AND THE JOB MARKET

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- Technological innovation:
  - rapidly integrated into the job market.
  - Can cause outdated learning curricula (Abdulrahman et al., 2022).

THE GAP BETWEEN EDUCATION AND THE JOB MARKET

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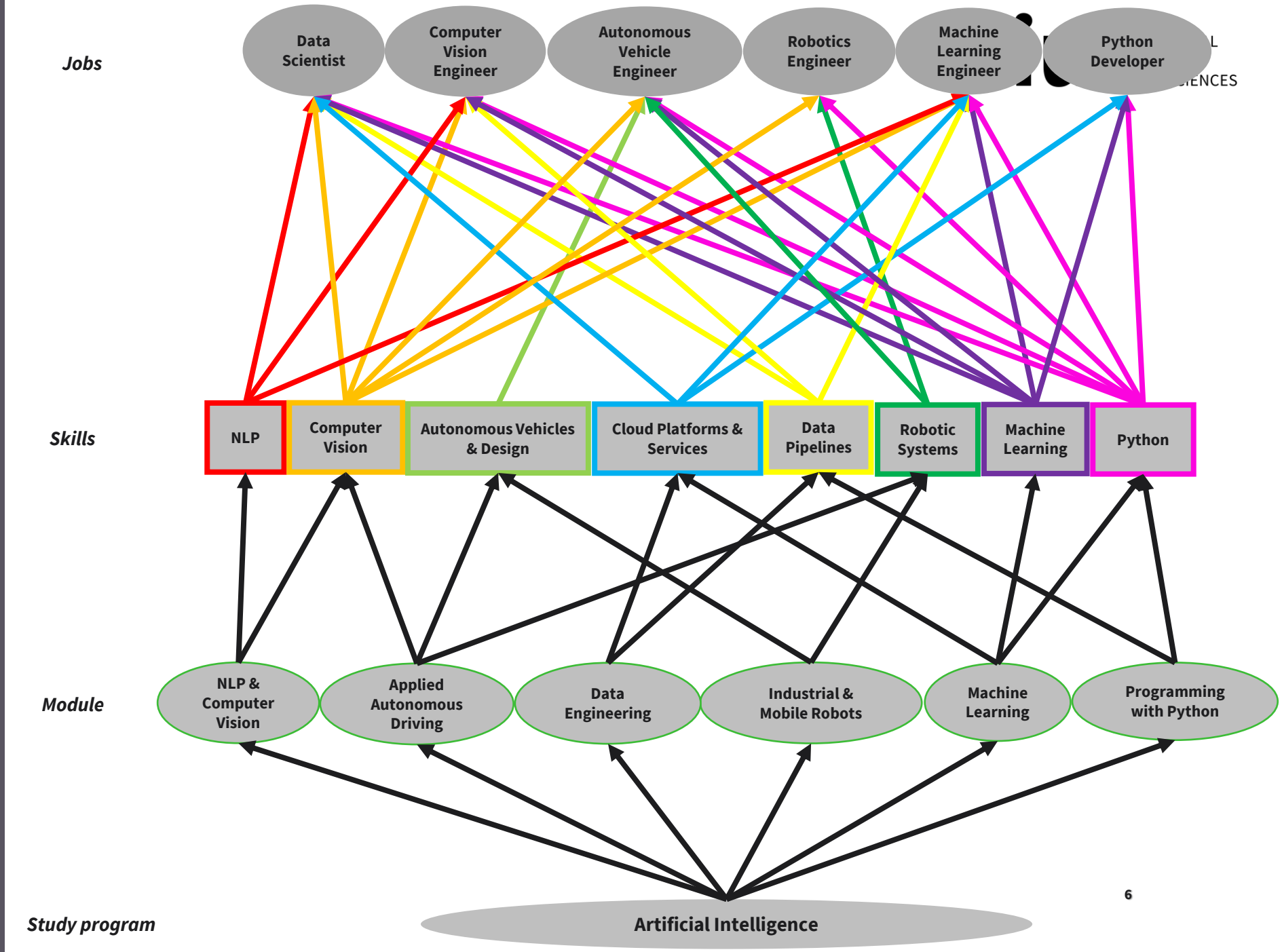
- Technological innovation:
  - rapidly integrated into the job market.
  - Can cause outdated learning curricula (Abdulrahman et al., 2022).

- Problems?
  - Graduates lack relevant skills.
  - Unemployment
  - Impedes progress towards goal 4 of UN's Sustainable Development Agenda (Elfert, 2019)

Our goal:

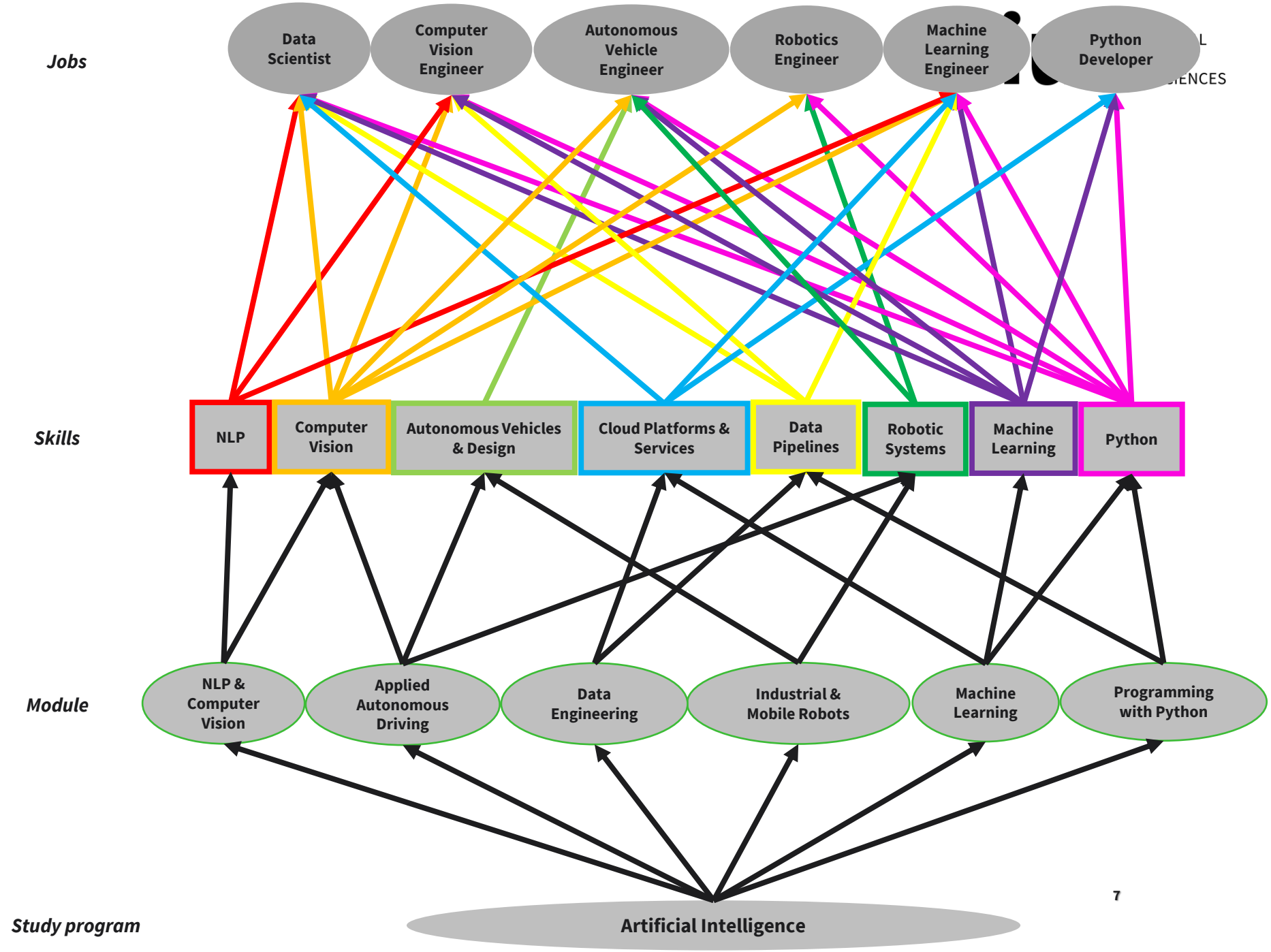
Using AI to compare learning materials and the current needs of the job market.



Our goal:

Using AI to compare learning materials and the current needs of the job market.

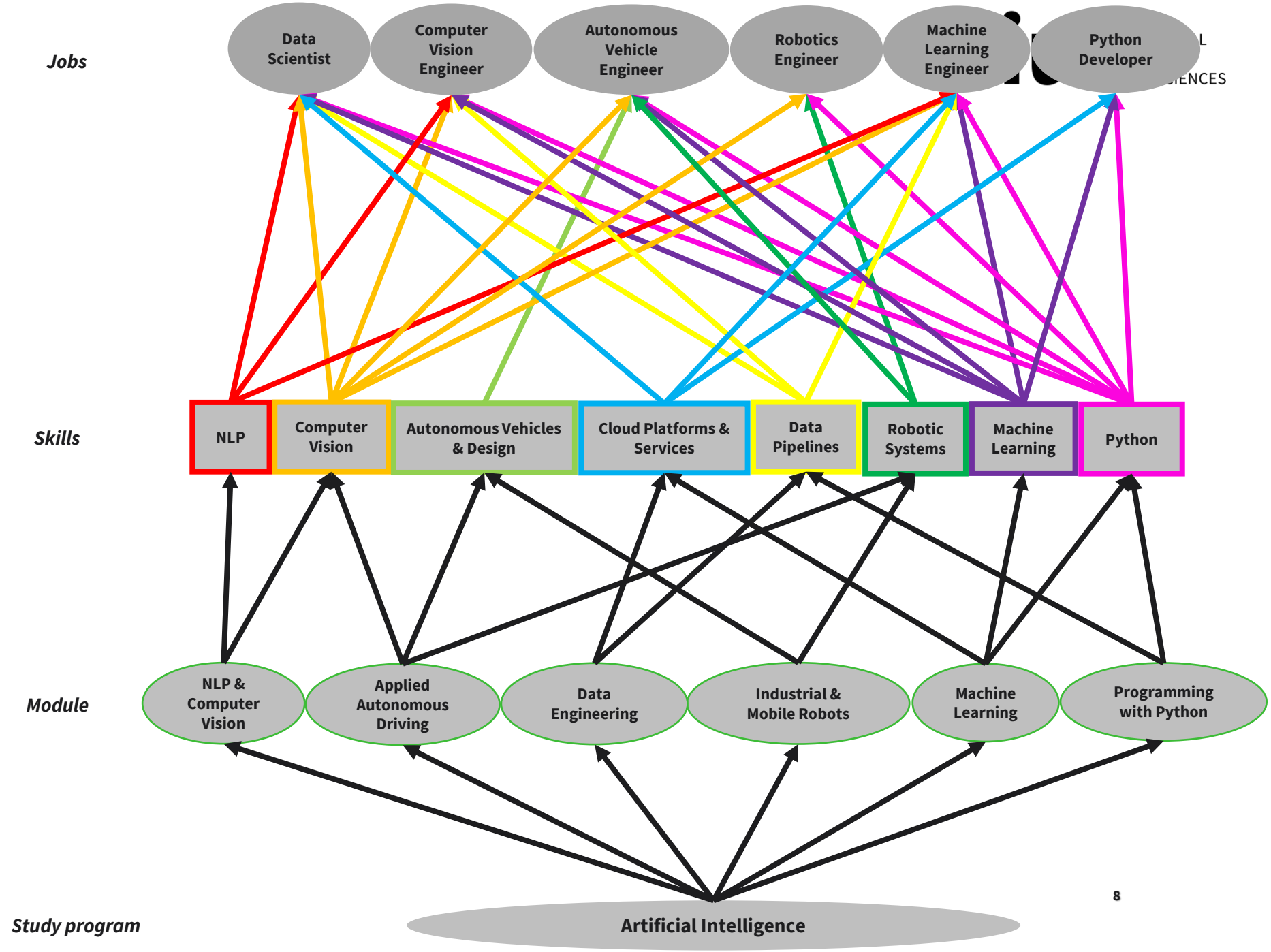
➔ Motivate students
➔ inform students



Our goal:

Using AI to compare learning materials and the current needs of the job market.

- ➔ Motivate students
- ➔ inform students
- ➔ Support teachers in keeping learning materials up-to-date



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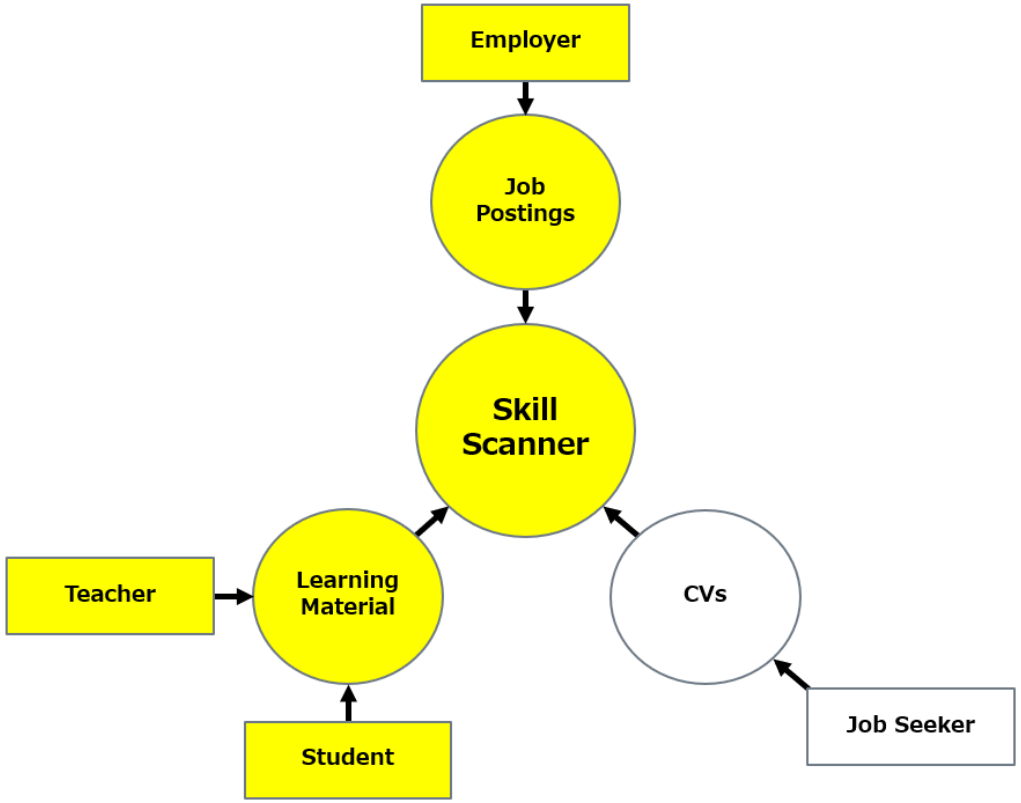
RELATED WORK

OUR PREVIOUS WORK

- **Skill Scanner** (Bothmer & Schlippe, 2022a, 2022b, 2023)
  - AI pipeline to connect skills of:
    - Employers
    - Educational institutions
    - Job seekers

- This work
  - leverages Skill Scanner.
  - Focuses on Education-Job Market alignment.



Skill Scanner: An AI-Based Recommendation System for Employers, Job Seekers and Educational Institutions. Koen Bothmer and Tim Schlippe. International Journal of Advanced Corporate Learning (iJAC), 16(1), pp. 55-64, 13 March 2023

Investigating Natural Language Processing Techniques for a Recommendation System to Support Employers, Job Seekers and Educational Institutions. Koen Bothmer and Tim Schlippe. In Proceedings of The 23rd International Conference on Artificial Intelligence in Education (AIED 2022), Durham, UK, 27-31 July 2022

Skill Scanner: Connecting and Supporting Employers, Job Seekers and Educational Institutions with an AI-based Recommendation System. Koen Bothmer and Tim Schlippe. In Proceedings of The Learning Ideas Conference 2022 (15th annual conference), New York, New York, 15-17 June 2022.

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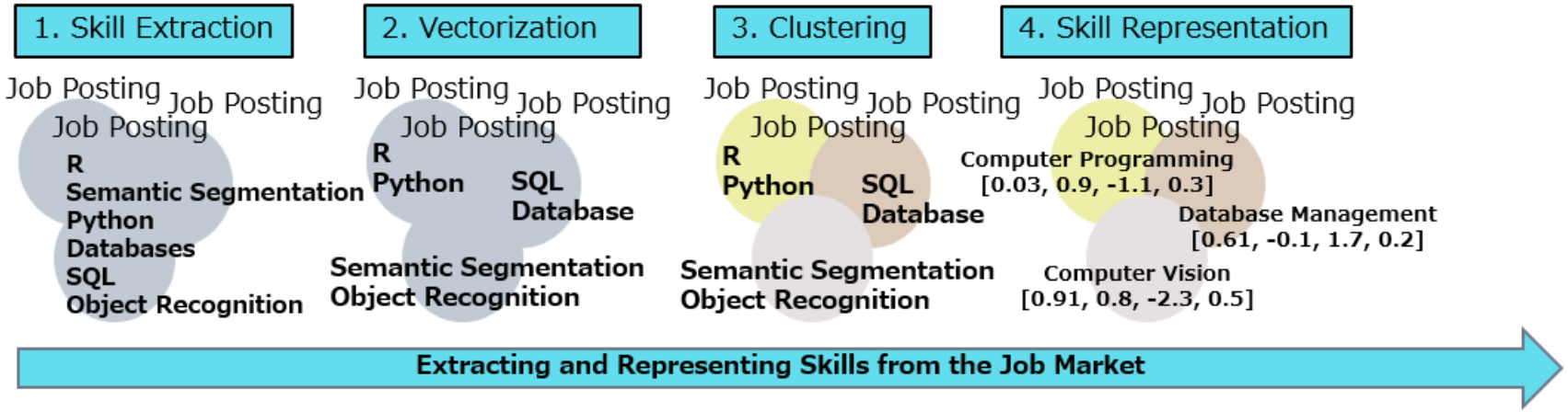
PIPELINE TO CONNECT LEARNING MATERIAL AND JOB POSTINGS

AI pipeline:

to Connect
Learning Material
and Job Postings



AI pipeline:

to Connect
Learning Material
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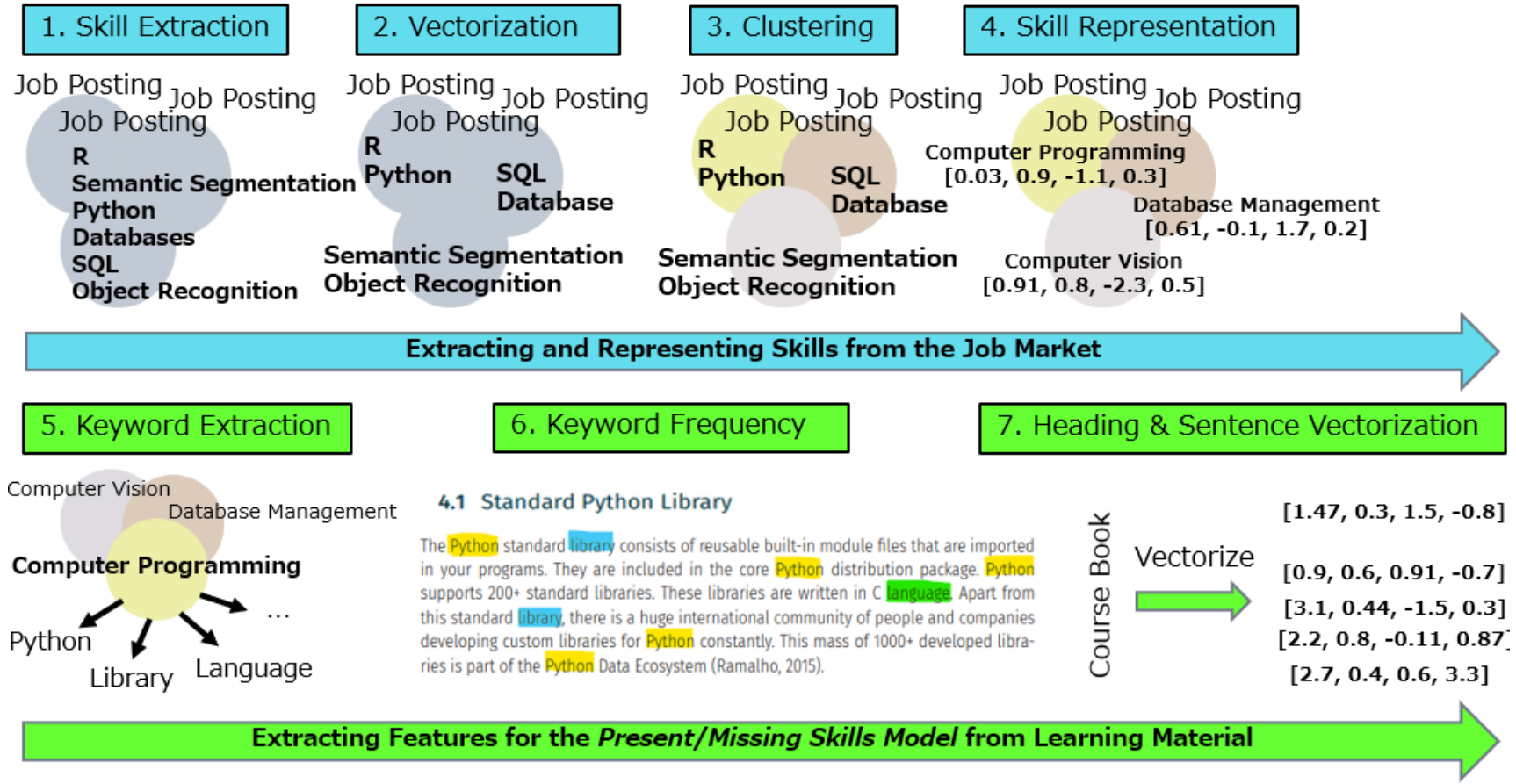

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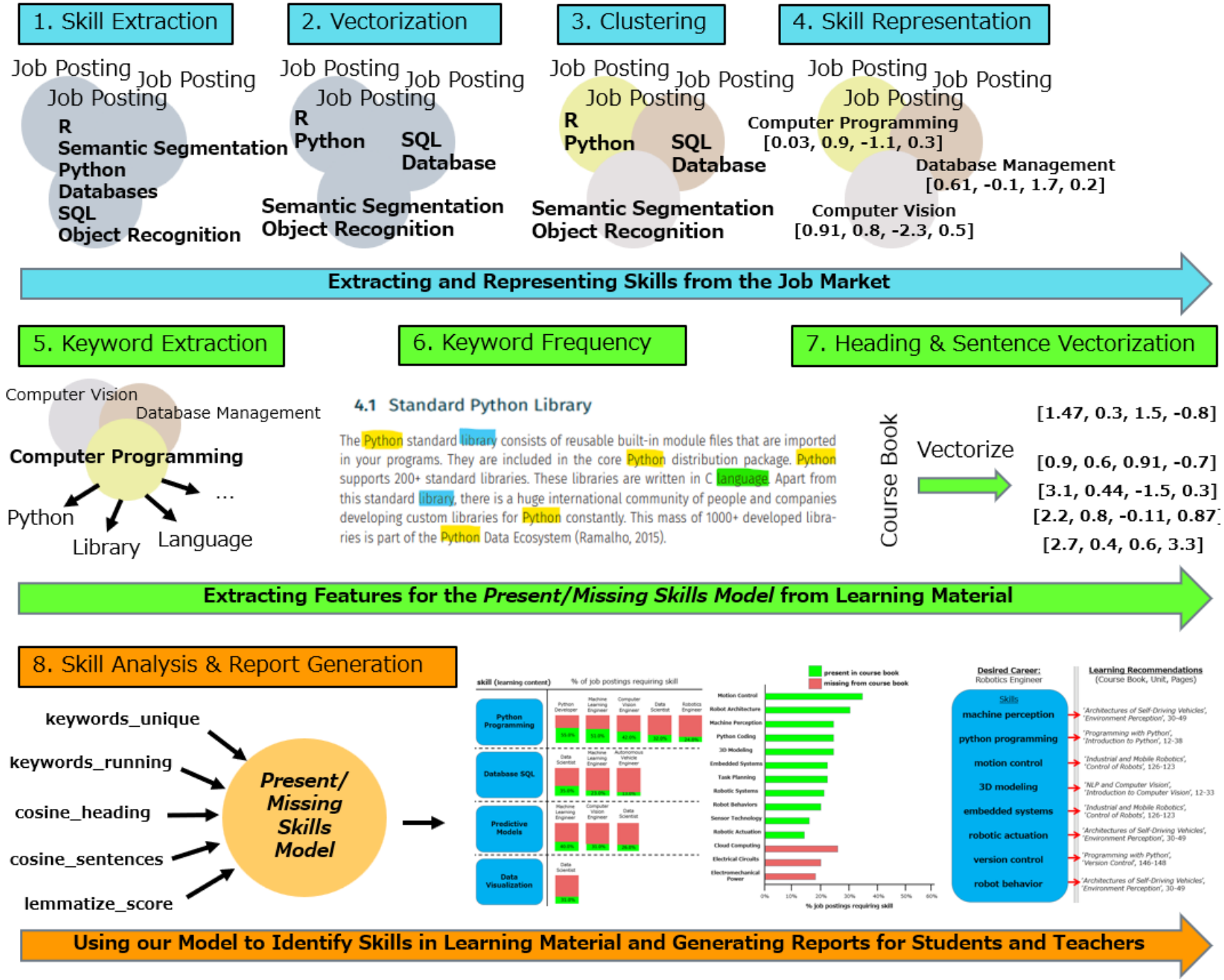
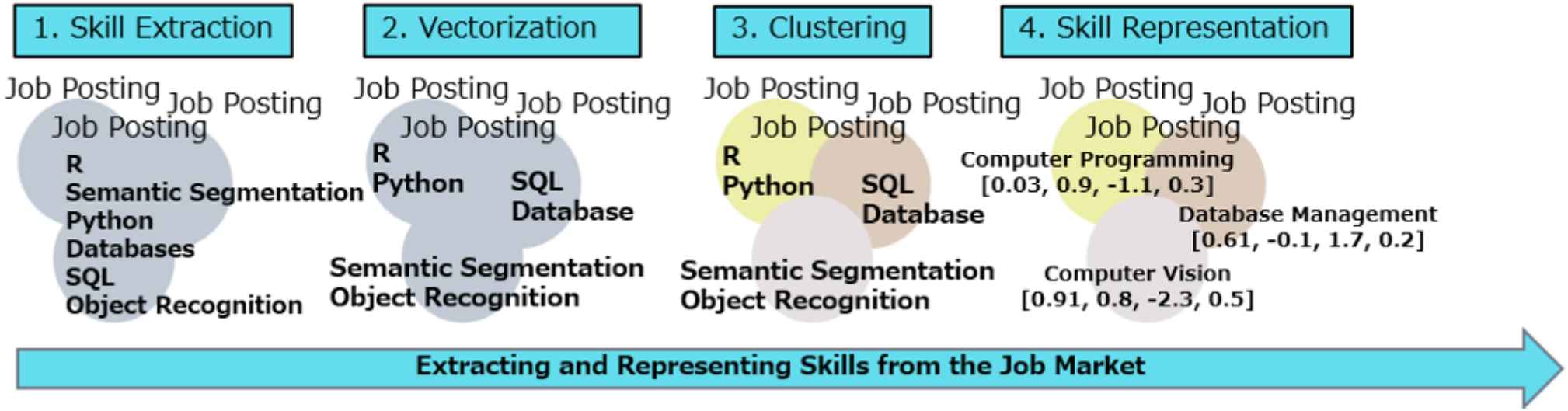
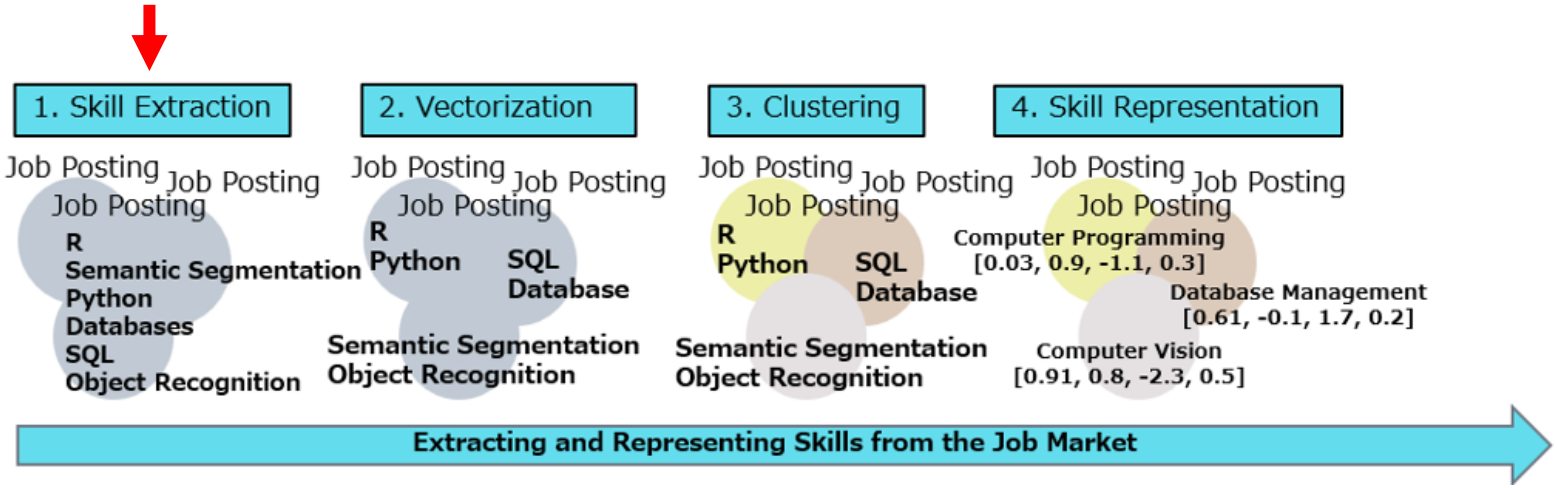


EXTRACTION OF SKILLS FROM THE JOB MARKET





Extraction of skills:

- Experiments with 600 job postings scraped from Indeed.com for the optimization of the AI pipeline
  - 100 x Autonomous Vehicle Engineer
  - 100 x Computer Vision Engineer
  - 100 x Data Scientist
  - 100 x Machine Learning Engineer
  - 100 x Python Developer
  - 100 x Robotics Engineer

- Extraction of skills from bullet points

```
<div>
  <div>
    <p><b>Desired Skills</b></p>
    <ul>
      <li>Strong problem-solving skills, ability to abstract out details and simplify a problem</li>
      <li>Strong programming skills in C/C++</li>
      <li>Knowledge of various python libraries such as NumPy, SciPy, and Matplotlib</li>
      <li>Strong background in algorithms and data structures.</li>
      <li>Knowledge of data mining and machine learning</li>
      <li>Knowledge of machine learning</li>
      <li>Strong interpersonal skills; able to work independently as well as in a team</li>
    </ul>
  </div>
</div>
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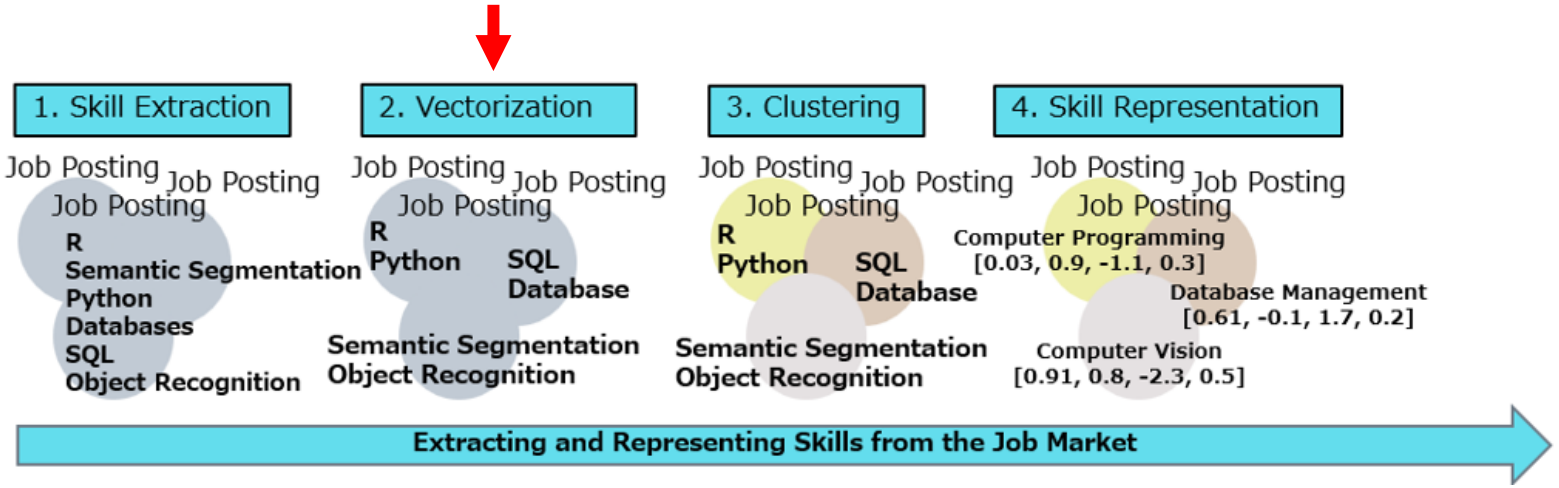
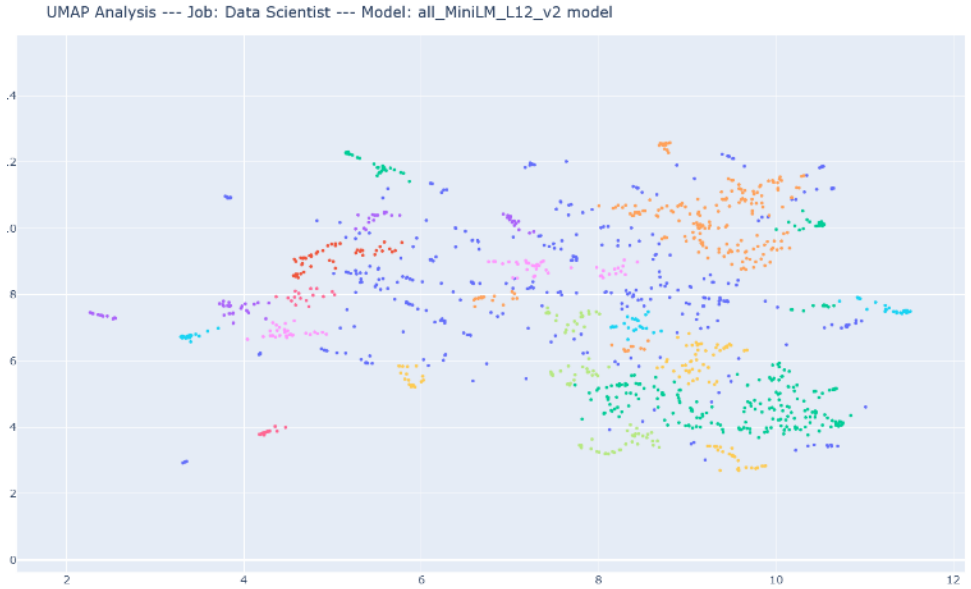
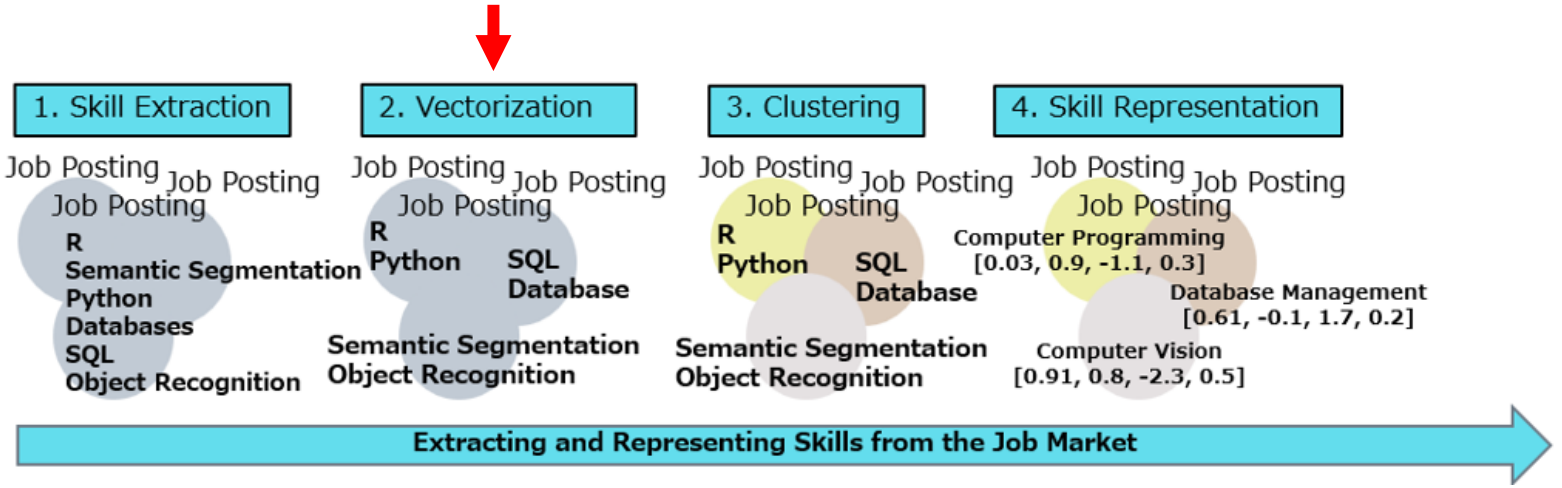


Conversion of skills into sentence vectors:

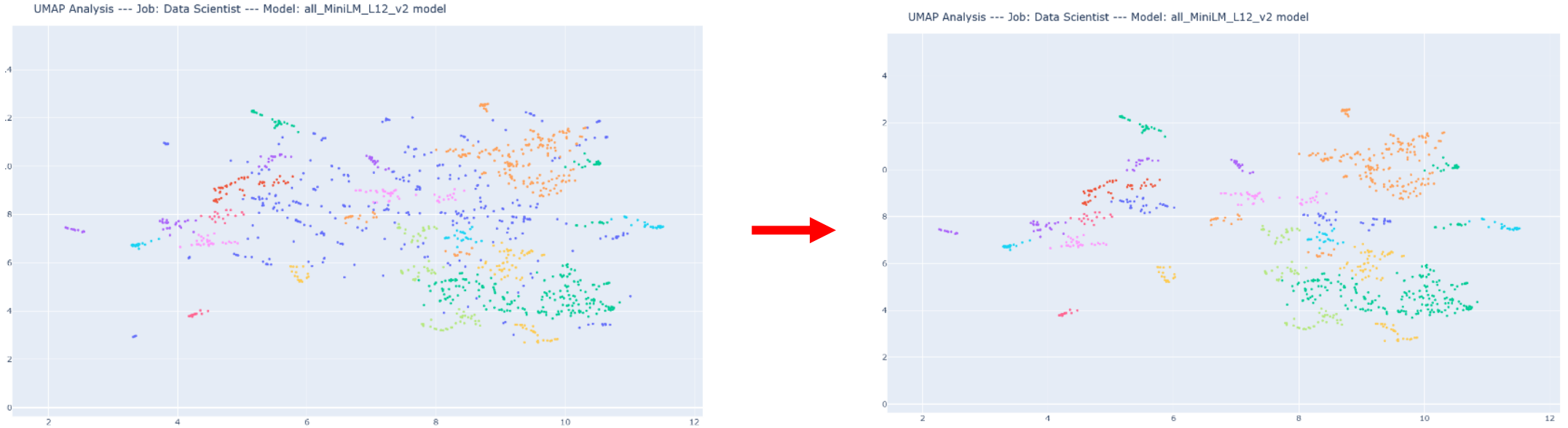
- **Sentence-BERT** for conversion of competencies to 768-dim. sentence vectors.

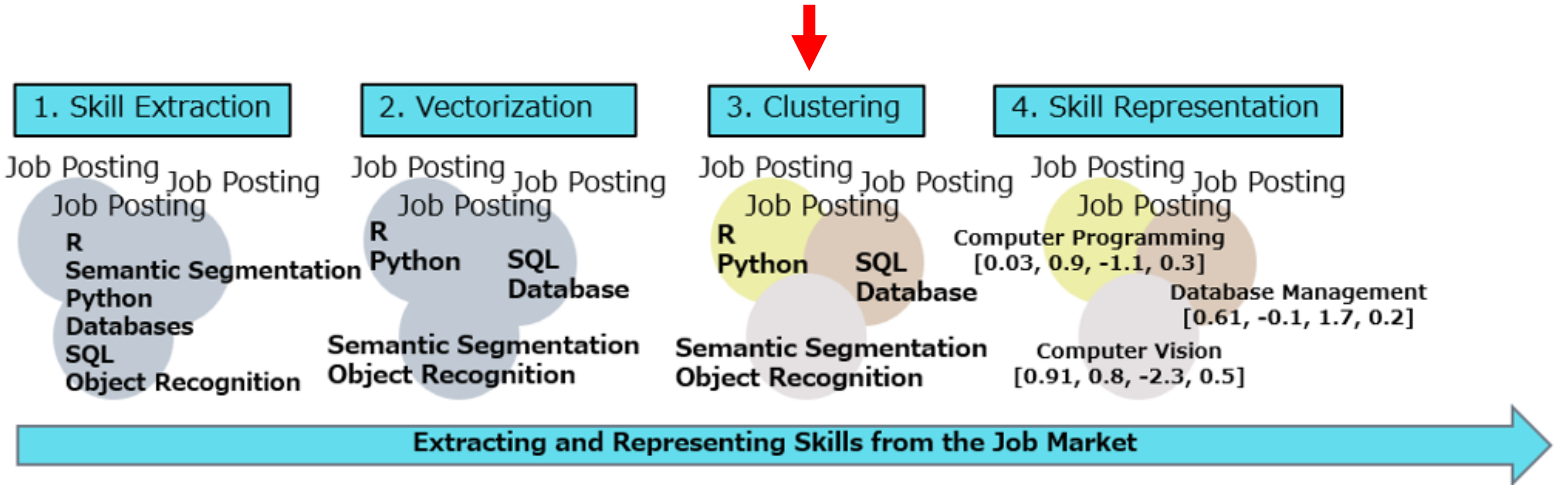




Conversion of skills into sentence vectors:

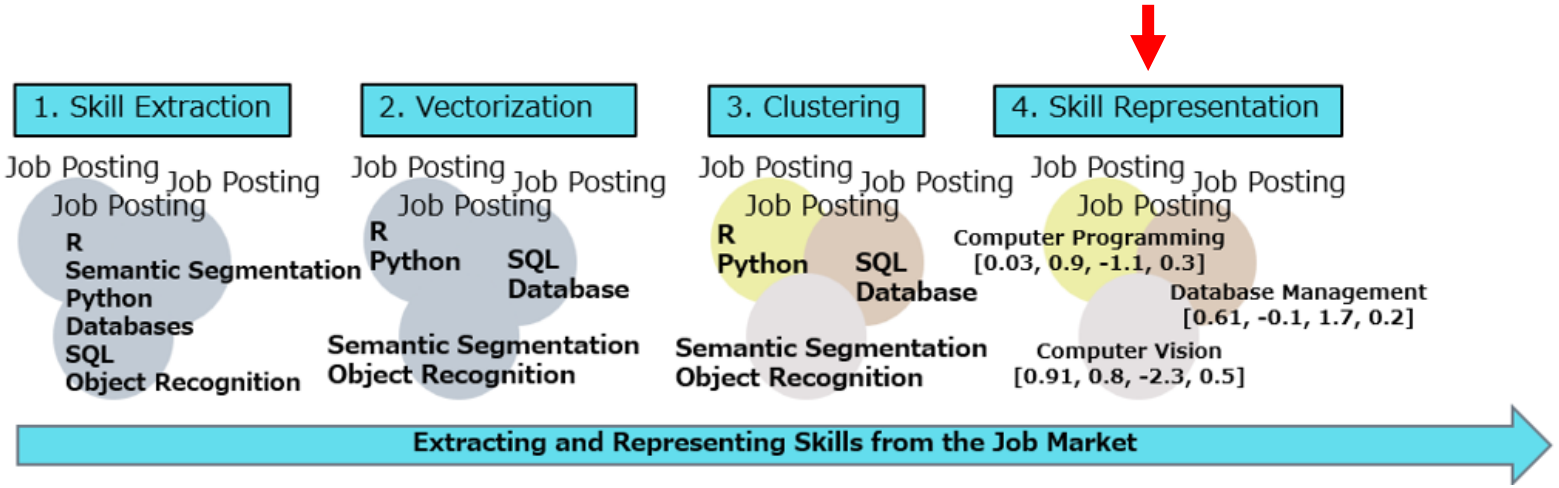
- **UMAP** to reduce the 768 dim. Sentence vectors into 2-dim. vectors and **DBSCAN** to remove outliers that are not competencies. ➔ Of 7,787 potential skills, 6,184 remain.





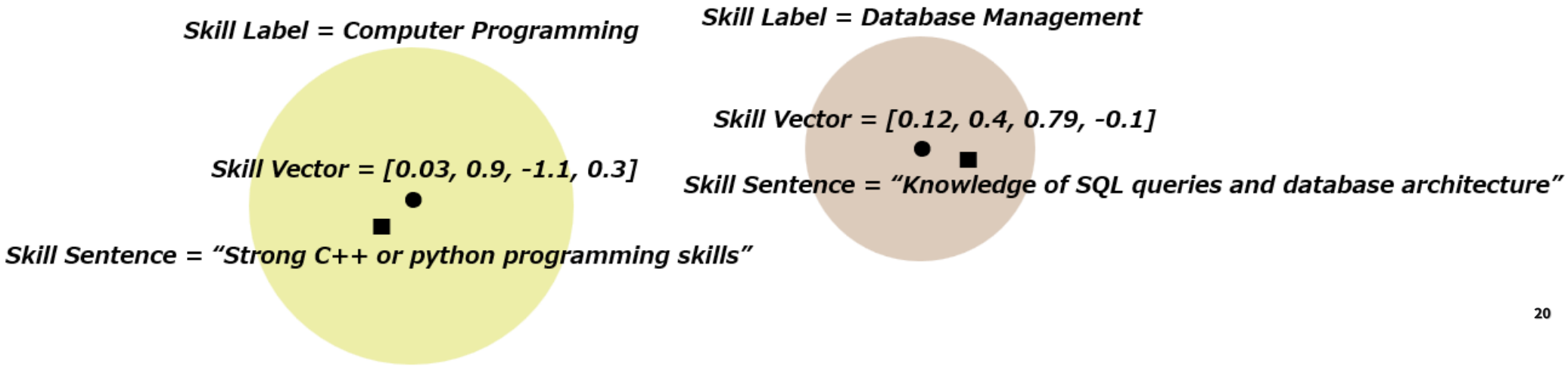
Clustering of sentence vectors to combine synonymous skills:

- **K-Means** clustering after mapping back the remaining 2-dim. vectors to 768 dimensions.



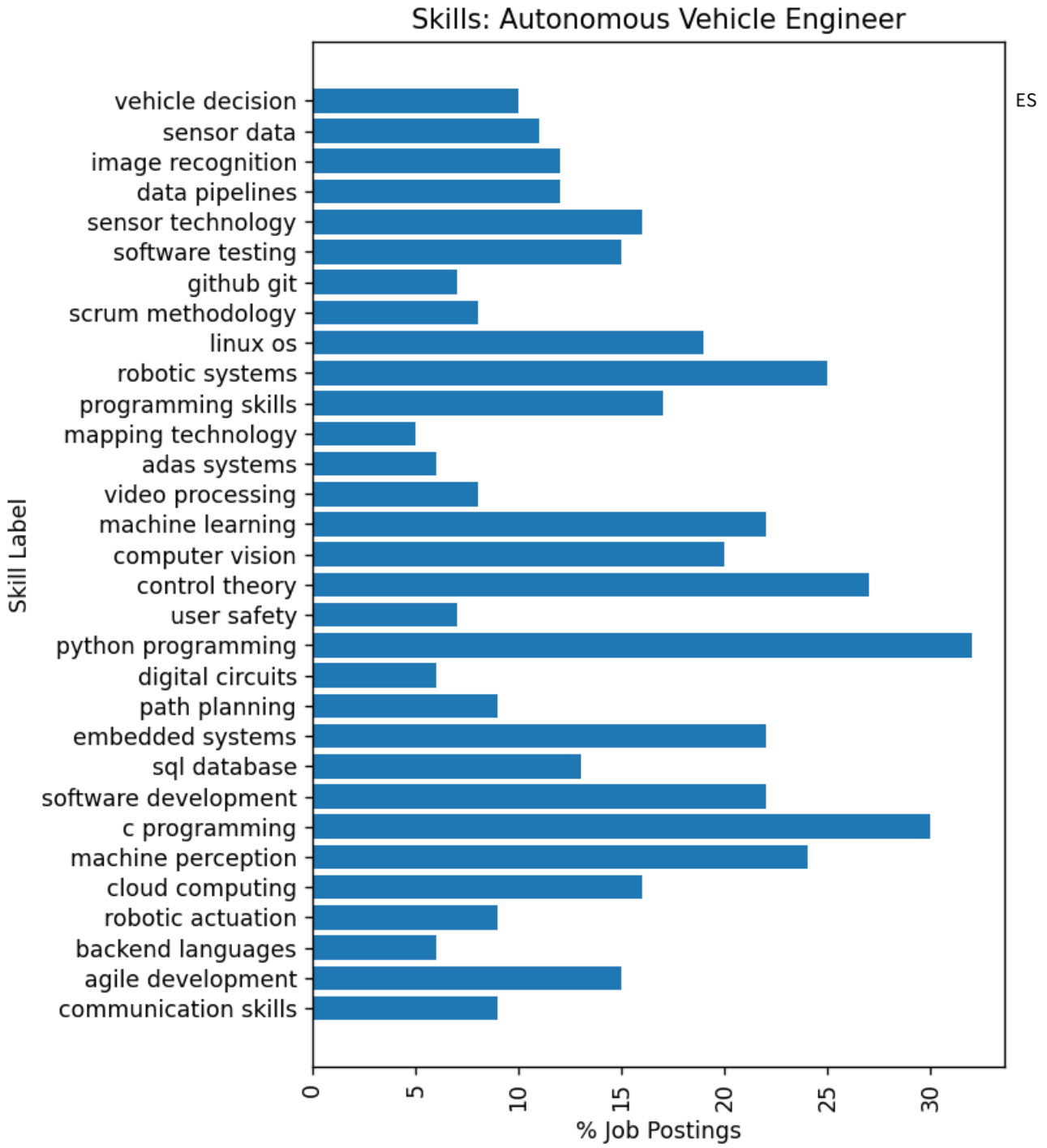
Skill Representation :

- 3 representations for each skill:
  - ***skill label***: most common bigram in cluster
  - ***skill vector***: average vector of each cluster
  - ***skill sentence***: skill requirement sentence closest to *skill vector*



For each Job Position:

➔ List of Required Skills
➔ Importance of Each Skill



FEATURES FOR COMPARISON WITH LEARNING MATERIAL

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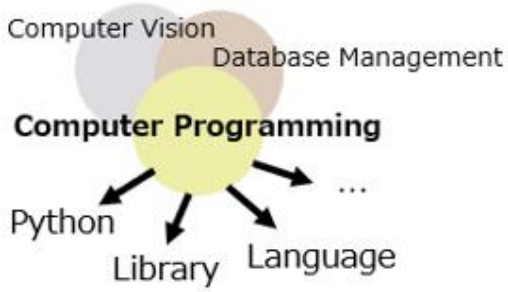
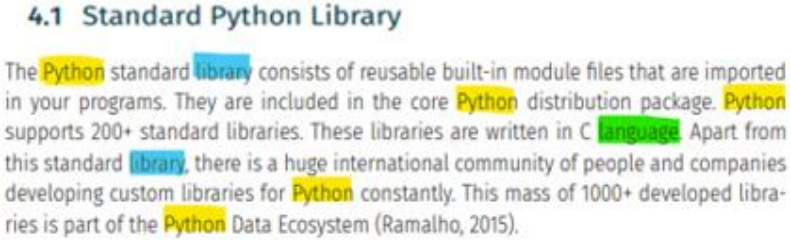
5. Keyword Extraction



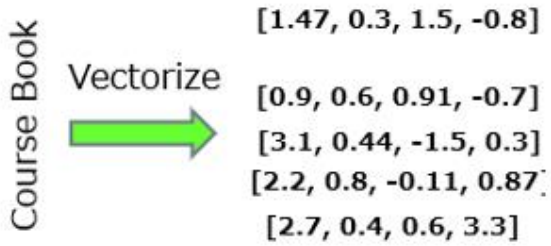
6. Keyword Frequency



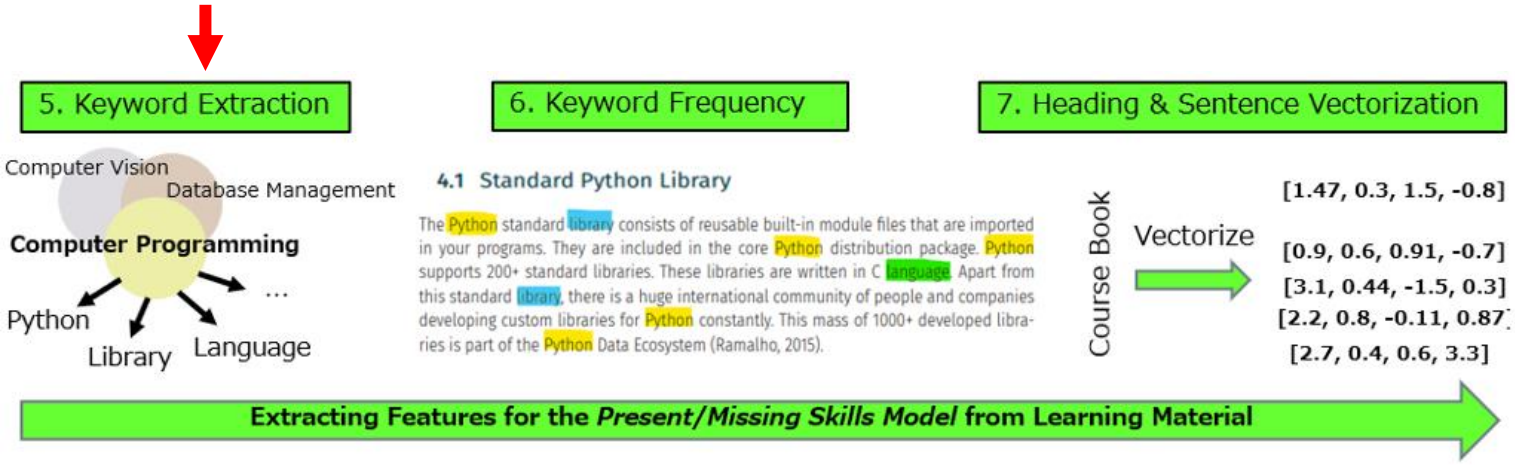
4.1 Standard Python Library

The Python standard library consists of reusable built-in module files that are imported in your programs. They are included in the core Python distribution package. Python supports 200+ standard libraries. These libraries are written in C language. Apart from this standard library, there is a huge international community of people and companies developing custom libraries for Python constantly. This mass of 1000+ developed libraries is part of the Python Data Ecosystem (Ramalho, 2015).

7. Heading & Sentence Vectorization

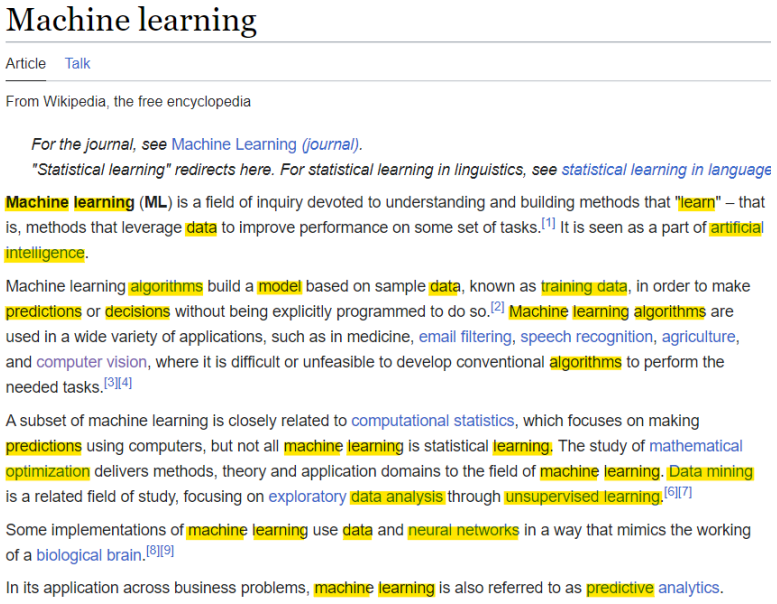


Extracting Features for the *Present/Missing Skills Model* from Learning Material



Extraction of further words (keywords), which fit to each skill:

- from Wikipedia pages
- using **TF-IDF** → Extraction of 15 keywords for each skill



Machine learning

Article Talk

From Wikipedia, the free encyclopedia

For the journal, see Machine Learning *(journal).*
"Statistical learning" redirects here. For statistical learning in linguistics, see statistical learning in language

Machine learning (**ML**) is a field of inquiry devoted to understanding and building methods that "learn" – that is, methods that leverage data to improve performance on some set of tasks.[1] It is seen as a part of artificial intelligence.

Machine learning algorithms build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so.[2] Machine learning algorithms are used in a wide variety of applications, such as in medicine, email filtering, speech recognition, agriculture, and computer vision, where it is difficult or unfeasible to develop conventional algorithms to perform the needed tasks.[3][4]

A subset of machine learning is closely related to computational statistics, which focuses on making predictions using computers, but not all machine learning is statistical learning. The study of mathematical optimization delivers methods, theory and application domains to the field of machine learning. Data mining is a related field of study, focusing on exploratory data analysis through unsupervised learning.[6][7]

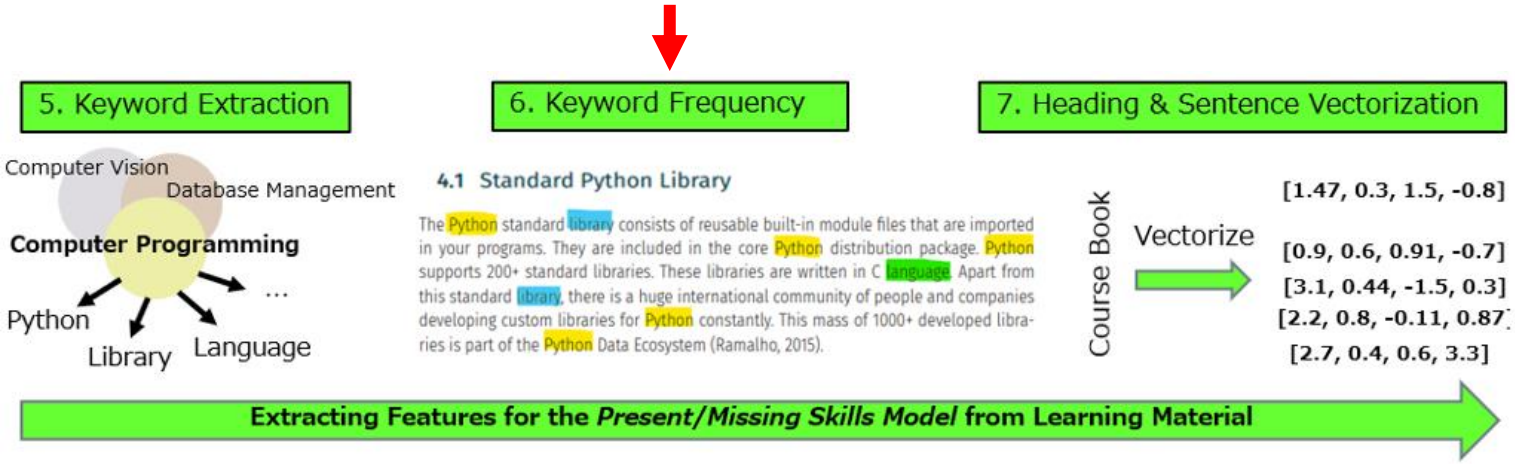
Some implementations of machine learning use data and neural networks in a way that mimics the working of a biological brain.[8][9]

In its application across business problems, machine learning is also referred to as predictive analytics.

Machine Learning
learn
data
algorithms
model
predictions
decisions
optimization
learning
machine
analysis
neural networks
unsupervised learning
artificial intelligence
training data
data mining

skill label

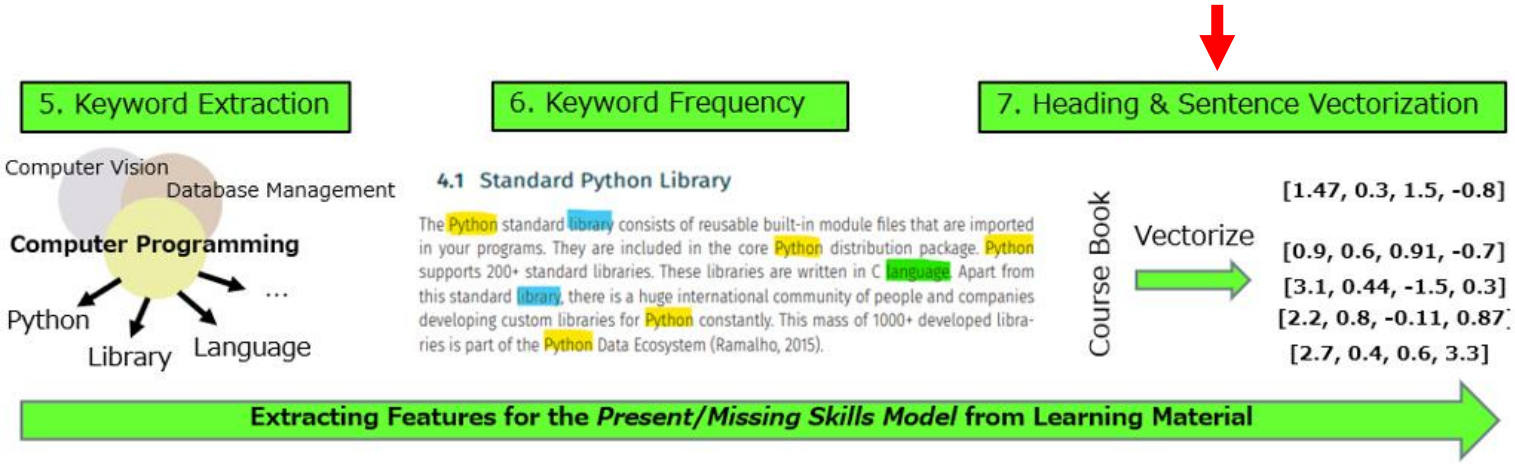
keywords



Keyword frequency in learning material :

- Search for keywords in learning material
  - ***keywords_unique*** = Number of keywords occurring (multiple keywords count 1 time)
  - ***keywords_running*** Number of keywords occurring (multiple keywords count multiple times)

Keyword Features



Conversion of learning material's headings and paragraphs to sentence vectors

- **Sentence-BERT** for conversion of headings and paragraphs into 768-dim. sentence vectors

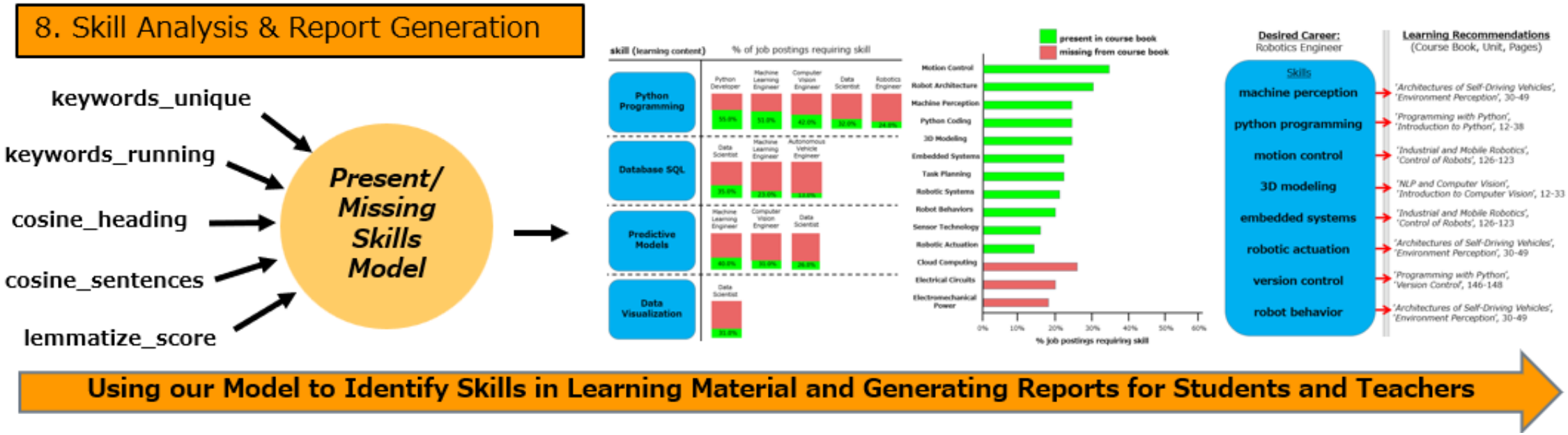
- **Cosine similarity** between vectorized headings and *skill vectors* = ***cosine_headings***
- **Cosine similarity** between vectorized sentences and *skill vectors* = ***cosine_sentences***

Sentence Vector Features

- **% matching lemmas** between learning material sentences and *skill sentences* = **lemmatize_score**

Lemmatization Feature

AI MODEL FOR ANALYSIS + GENERATION OF REPORTS



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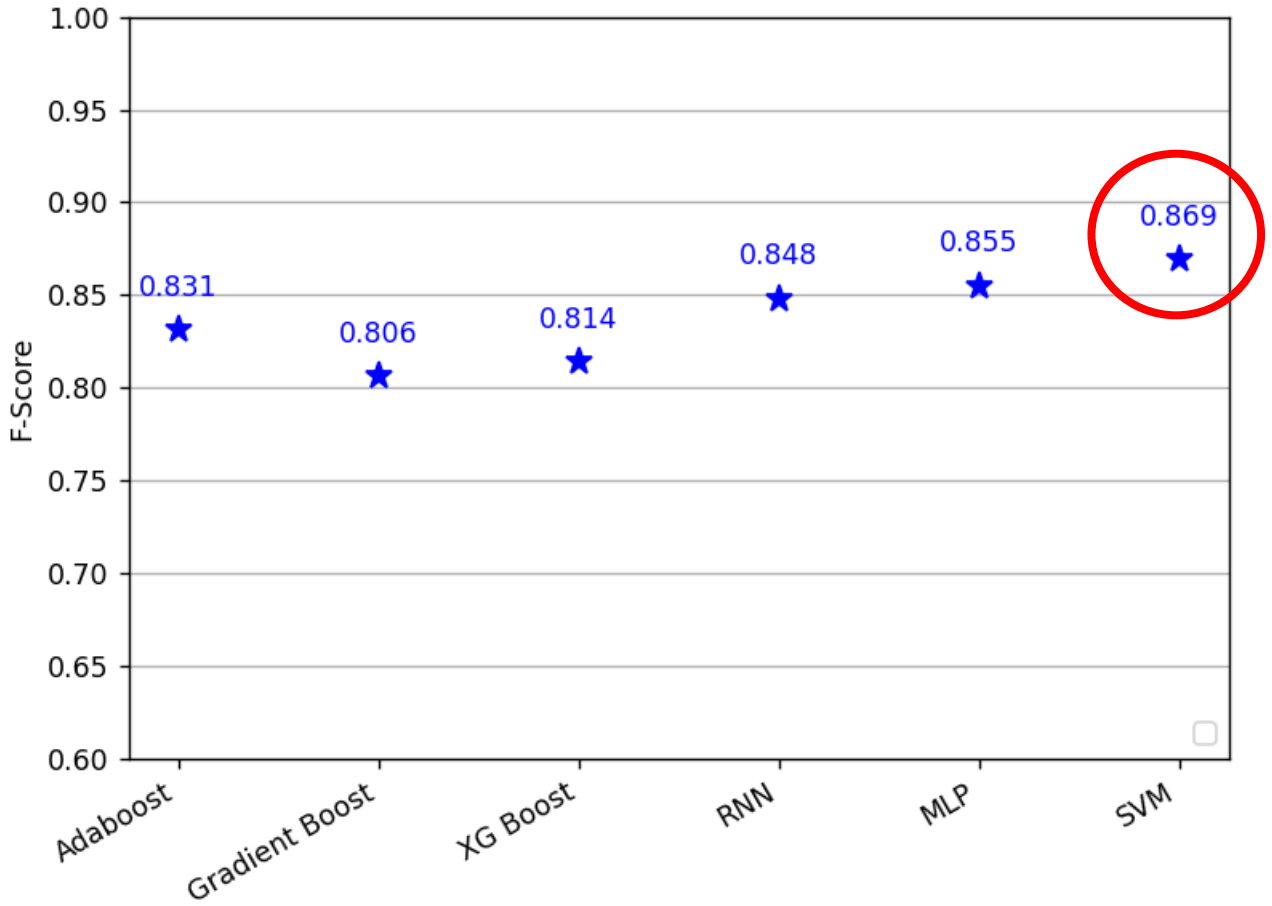
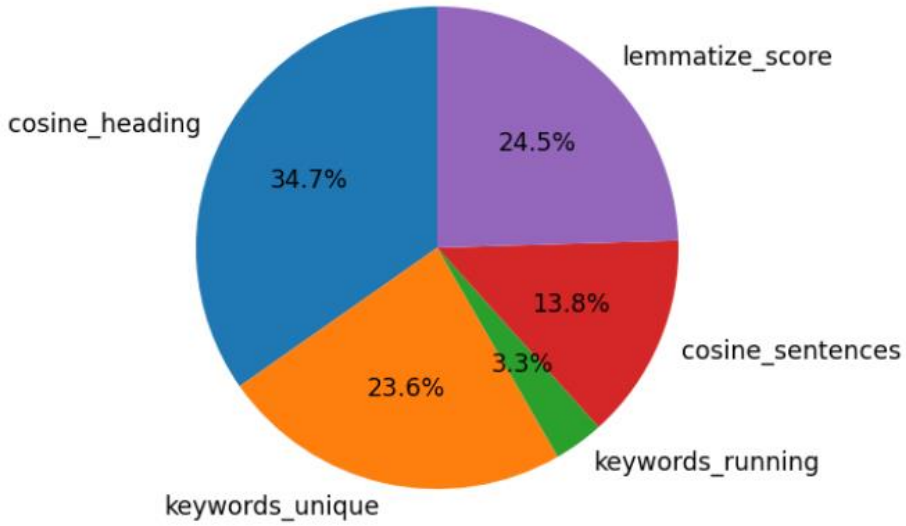
RESULTS

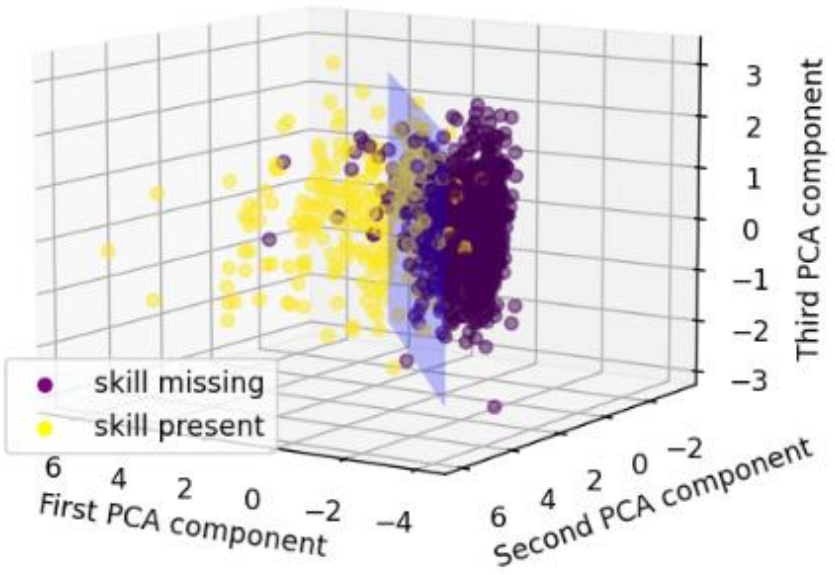
EVALUATION OF THE AI MODEL (F-SCORE)



BEST AI MODEL: SUPPORT VECTOR MACHINE

- Accuracy: 94.2%
- F-Score: 86.9%





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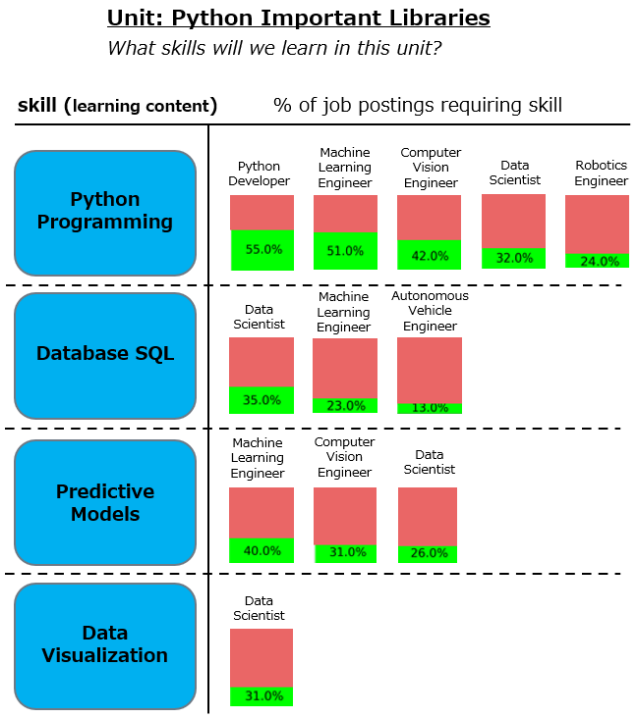
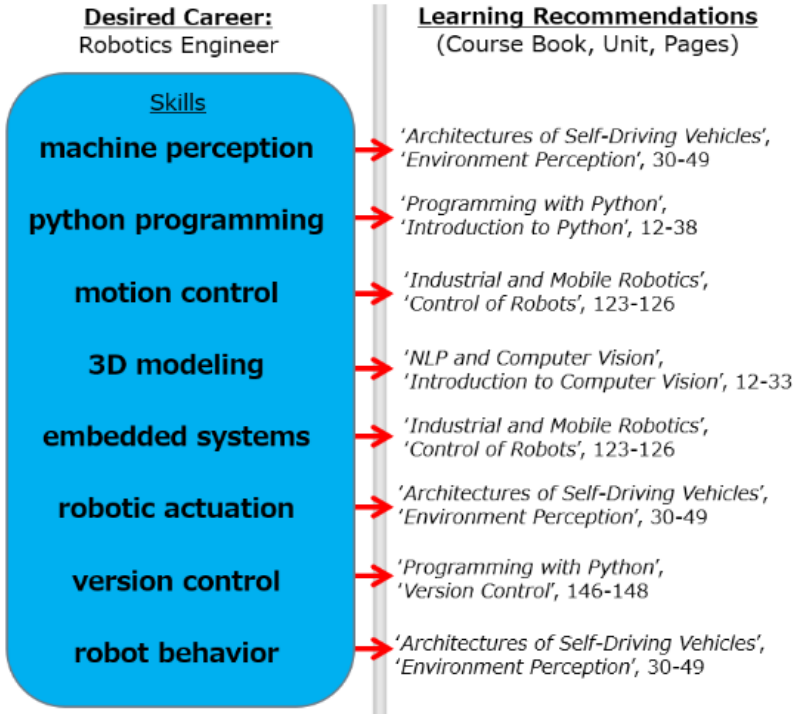
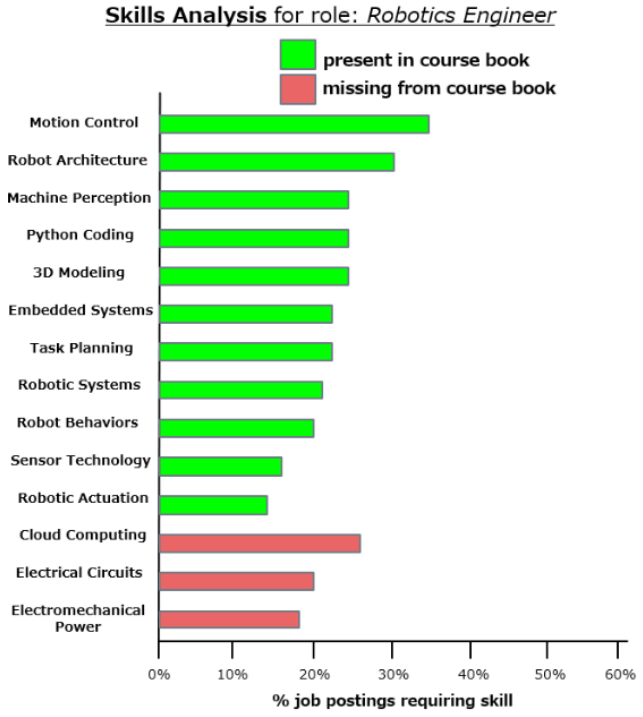
REPORTS

THE GAP BETWEEN EDUCATION AND THE JOB MARKET







THE GAP BETWEEN EDUCATION AND THE JOB MARKET

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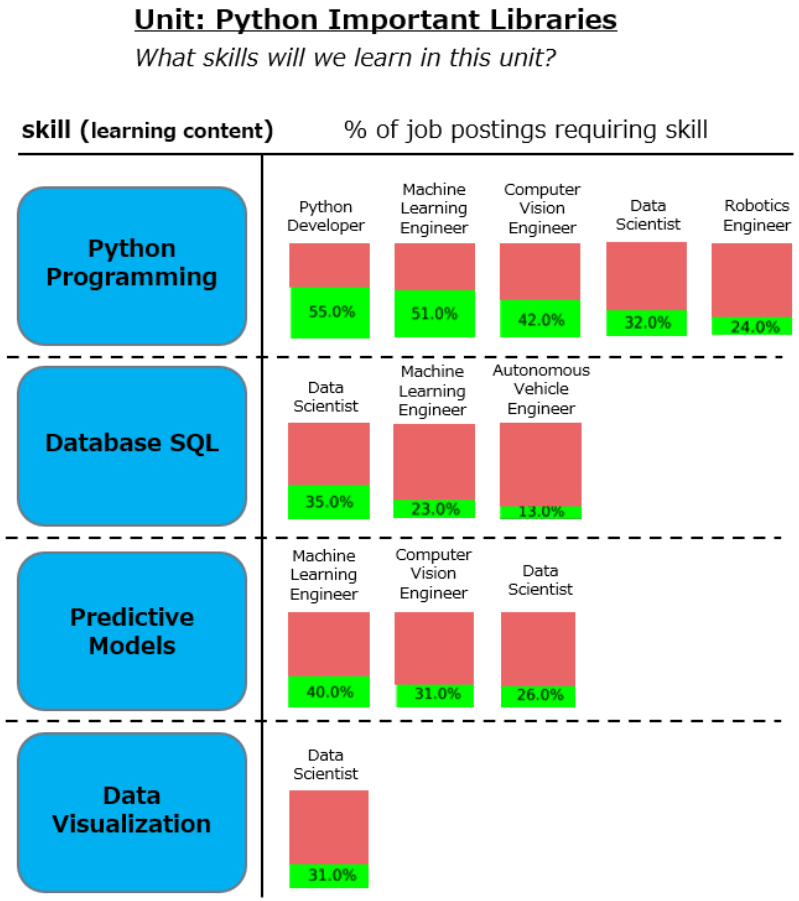
Student: „Why do I need to learn the learning material?“

LearningContent-JobMarket Report for Students



THE GAP BETWEEN EDUCATION AND THE JOB MARKET

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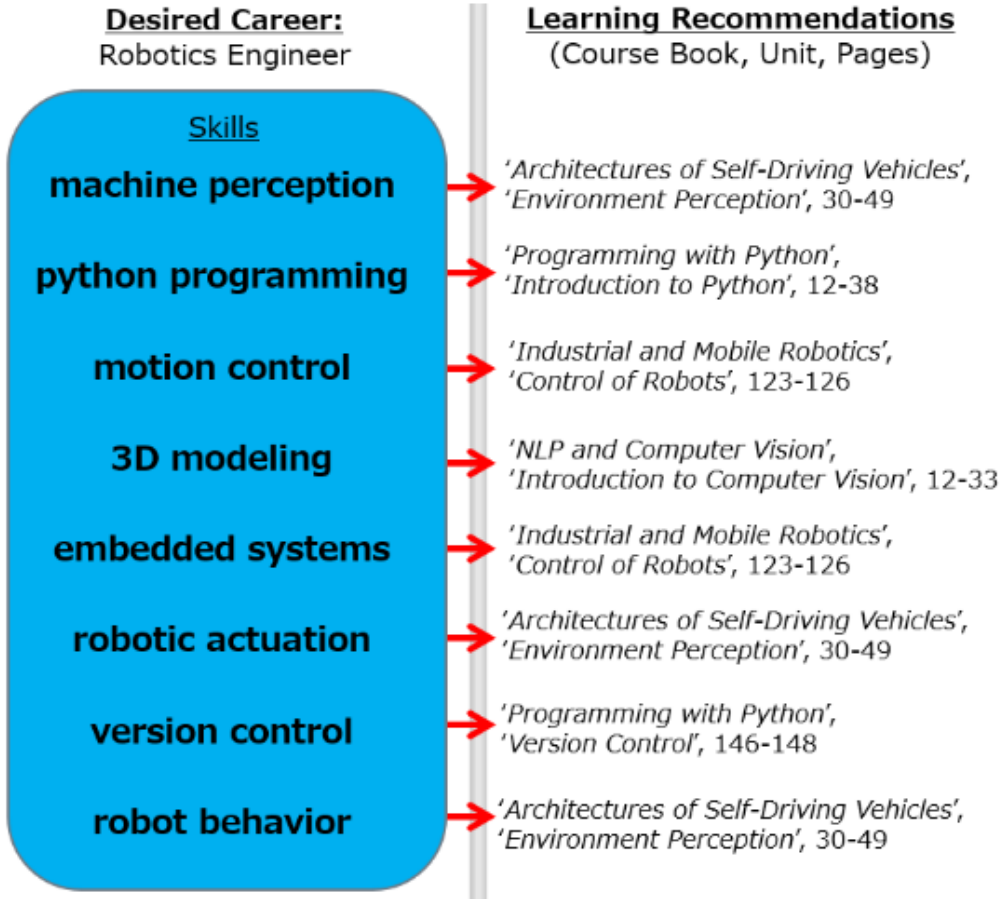
Student: „Where can I find more learning material that helps me with my career?“

Job-LearningPath Report for Students



THE GAP BETWEEN EDUCATION AND THE JOB MARKET

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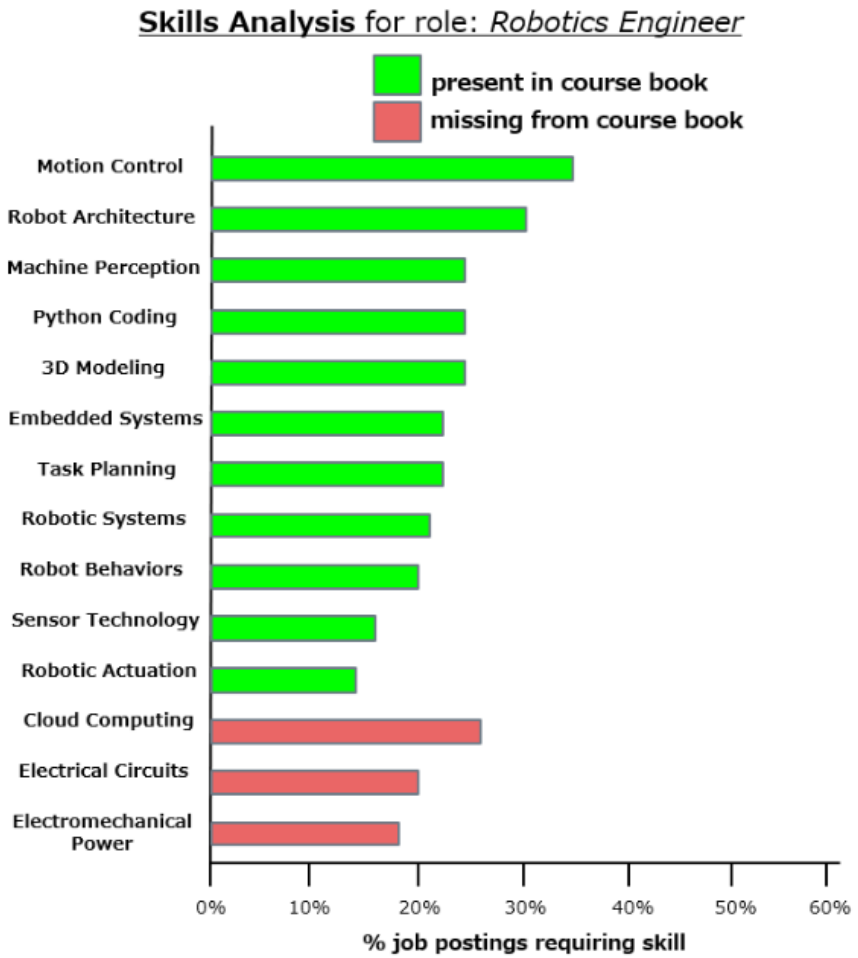
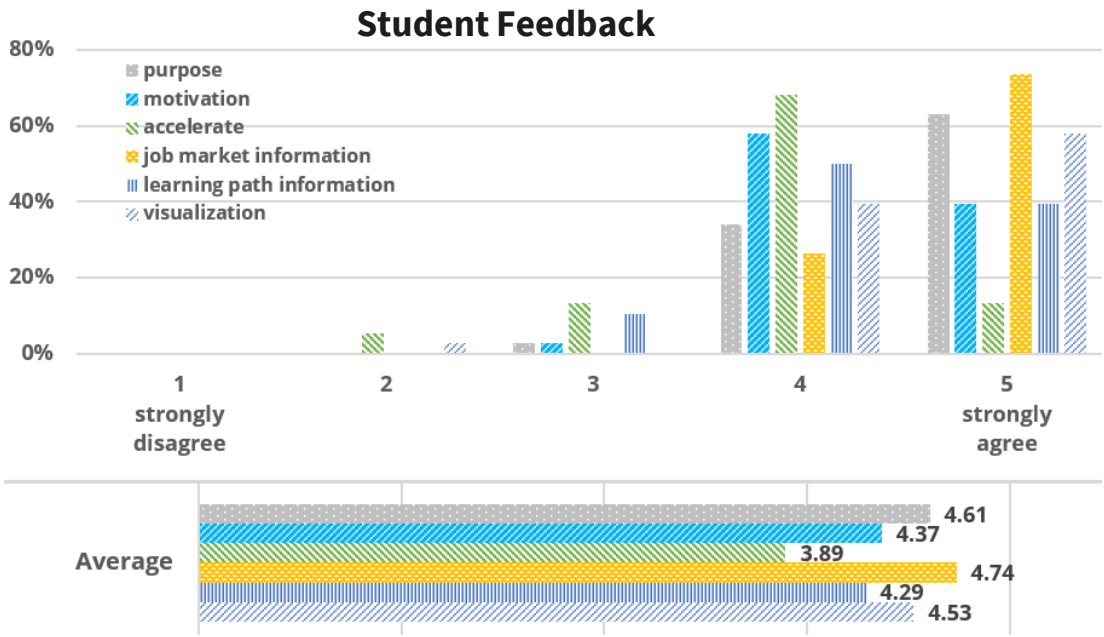
Teacher: „How can I ensure to cover the most relevant learning material?“

LearningContent-JobMarket Report for Teachers



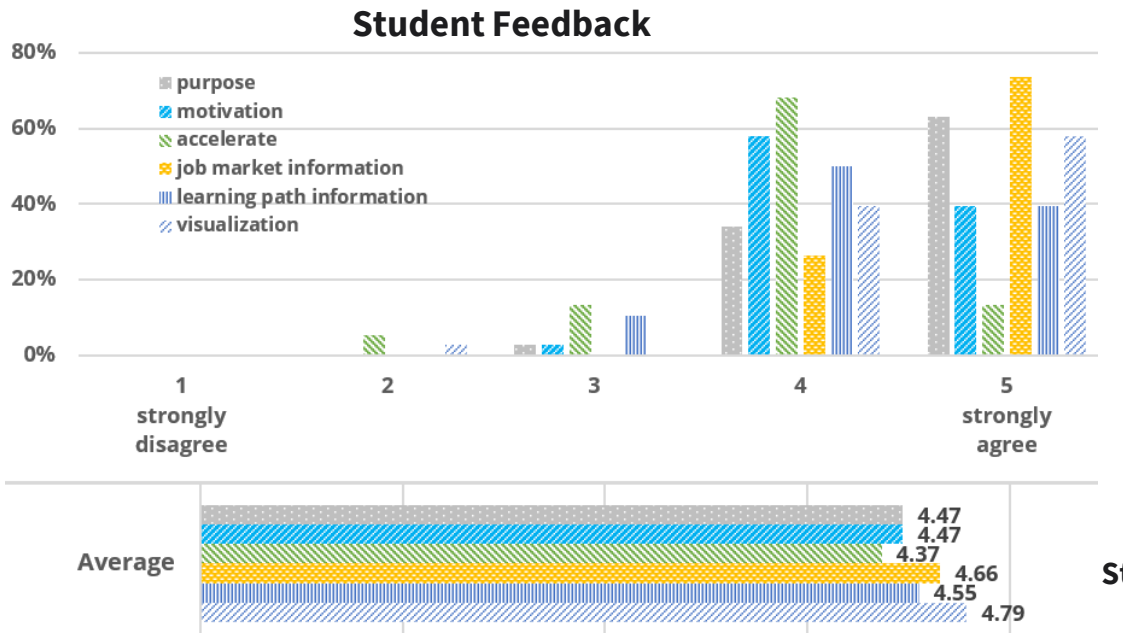
LearningContent-JobMarket Report for Students



Student Overall Average = 4.41

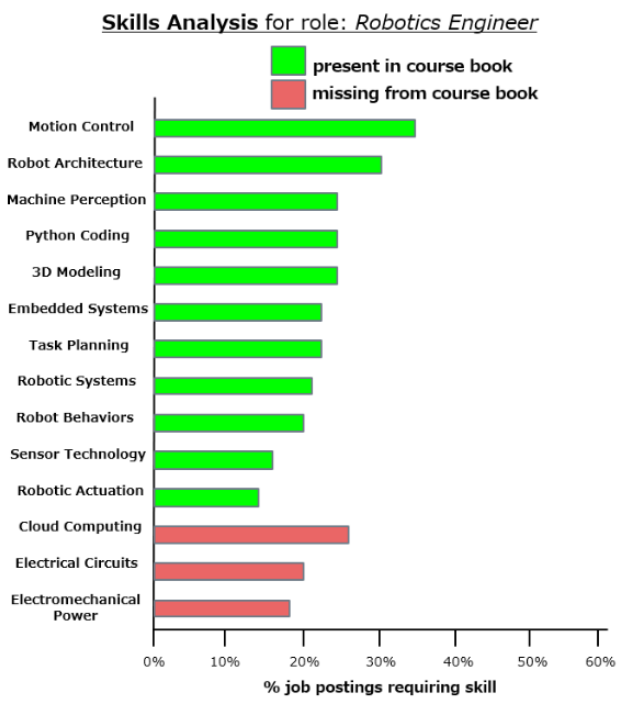
Job-LearningPath Report for Students

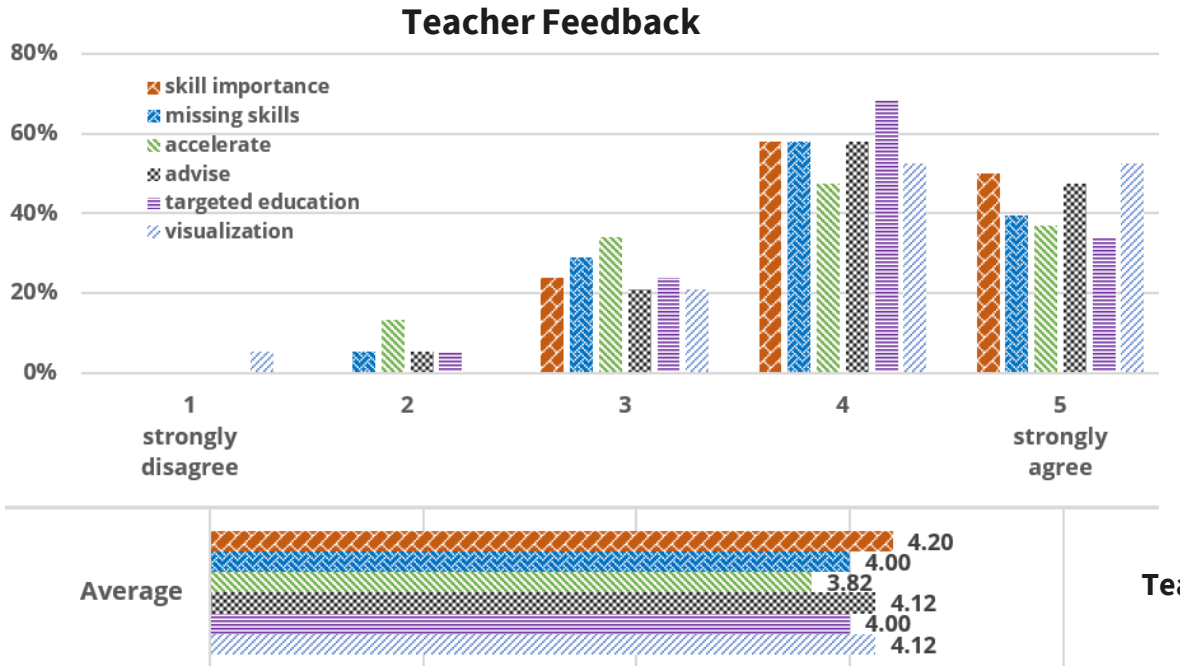
Desired Career: Robotics Engineer Skills	Learning Recommendations (Course Book, Unit, Pages)
machine perception	*'Architectures of Self-Driving Vehicles', 'Environment Perception'*, 30-49
python programming	*'Programming with Python', 'Introduction to Python'*, 12-38
motion control	*'Industrial and Mobile Robotics', 'Control of Robots'*, 123-126
3D modeling	*'NLP and Computer Vision', 'Introduction to Computer Vision'*, 12-33
embedded systems	*'Industrial and Mobile Robotics', 'Control of Robots'*, 123-126
robotic actuation	*'Architectures of Self-Driving Vehicles', 'Environment Perception'*, 30-49
version control	*'Programming with Python', 'Version Control'*, 146-148
robot behavior	*'Architectures of Self-Driving Vehicles', 'Environment Perception'*, 30-49



Student Overall Average = 4.55

LearningContent-JobMarket Report for Teachers





Teacher Overall Average = 4.04

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CONCLUSION & FUTURE WORK

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Conclusion

- **AI system:** identify job skills in learning material (accuracy 94.2% and F-score 86.9%)
- **2 Reports for Students**:
  - Show purpose of learning material
  - Motivate students
  - Accelerate learning process
  - Job market information
- **1 Report for Teachers**:
  - Skills present and missing in learning material.
  - Accelerate learning material creation.
  - Help advise students

CONCLUSION & FUTURE WORK

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Future Work

- More job postings
- Further optimization of the parameters
- Soft skills

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THANK YOU

Tim Schlippe
tim.schlippe@iu.org

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