Bridging the Knowledge Gap: Identifying Essential Machine Learning Concepts for Effective Progression in Follow-Up Courses

Liselotte Jongejans
TU Delft
Supervisor: Gosia Migut

1. Background

- Prepare students for all machine learning (ML) containing courses (and possibly careers)
- Create all-encompassing course that students can refer back to when studying follow-up courses

"Which (basic) knowledge concepts of Machine Learning need to be taught during CSE2510, to prepare students for follow-up courses?"

2. Objectives

- Build a road map of courses throughout TU Delft programs, to determine which courses cover ML
- Determine which concepts need to be added to / removed from the course in order for students to be prepared for follow-up courses

3. Methodology

- Literature review (although limited previous research). Read what previous research recommends to be taught in introductory ML course. Consult ACM competencies for undergraduate students to see whether all concepts mentioned are taught in CSE2510
- Interview teaching staff of follow up courses. Ask what ML concepts are expected prior knowledge, and whether student typically struggle with certain basic ML concepts
- Survey students for their experience with follow-up courses. Ask students whether they were unfamiliar with introductory concepts

Machine Learning
- Data Mining
- Computational Intelligence
- Image Processing
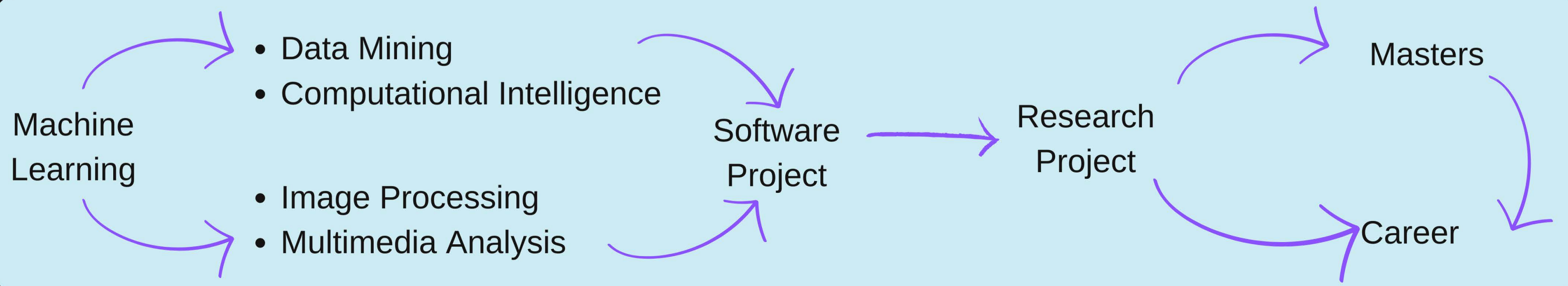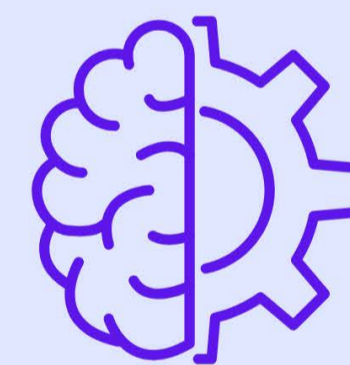- Multimedia Analysis
Software Project
Research Project
Masters
Career

Image of current ML road map in Bachelor

4. Results

- ACM Data Science Curricula report: solid understanding of various ML approaches including supervised learning and unsupervised learning, performance metrics, training and testing. Highlights significance of deep learning, emphasizing its status as a new and influential technique for large-scale learning
- Literature: ML models and algorithms, ML pipeline, training and testing, deep learning. Strike balance between theoretical understanding and practical application of ML algorithms. Help students understand and appreciate the connections between complex mathematical and ML concepts
- Interviews: theoretical understanding of ML algorithms, proficiency in working with datasets, strong understanding of PCA (students often struggle with this), understanding of loss functions, train / test / validation sets, mathematical notations, thorough understanding of Bayes' rule and linear algebra (students often struggle with matrix manipulations), deep learning. Multiple individuals teaching CSE2510, so course often focused on expertise of these individuals Main focus on theoretical understanding, leave practical to follow-up courses
- Surveys: significant number of respondents reported that CSE2510 adequately prepared them for follow-up courses. Desire for more hands-on explanations of mathematical concepts
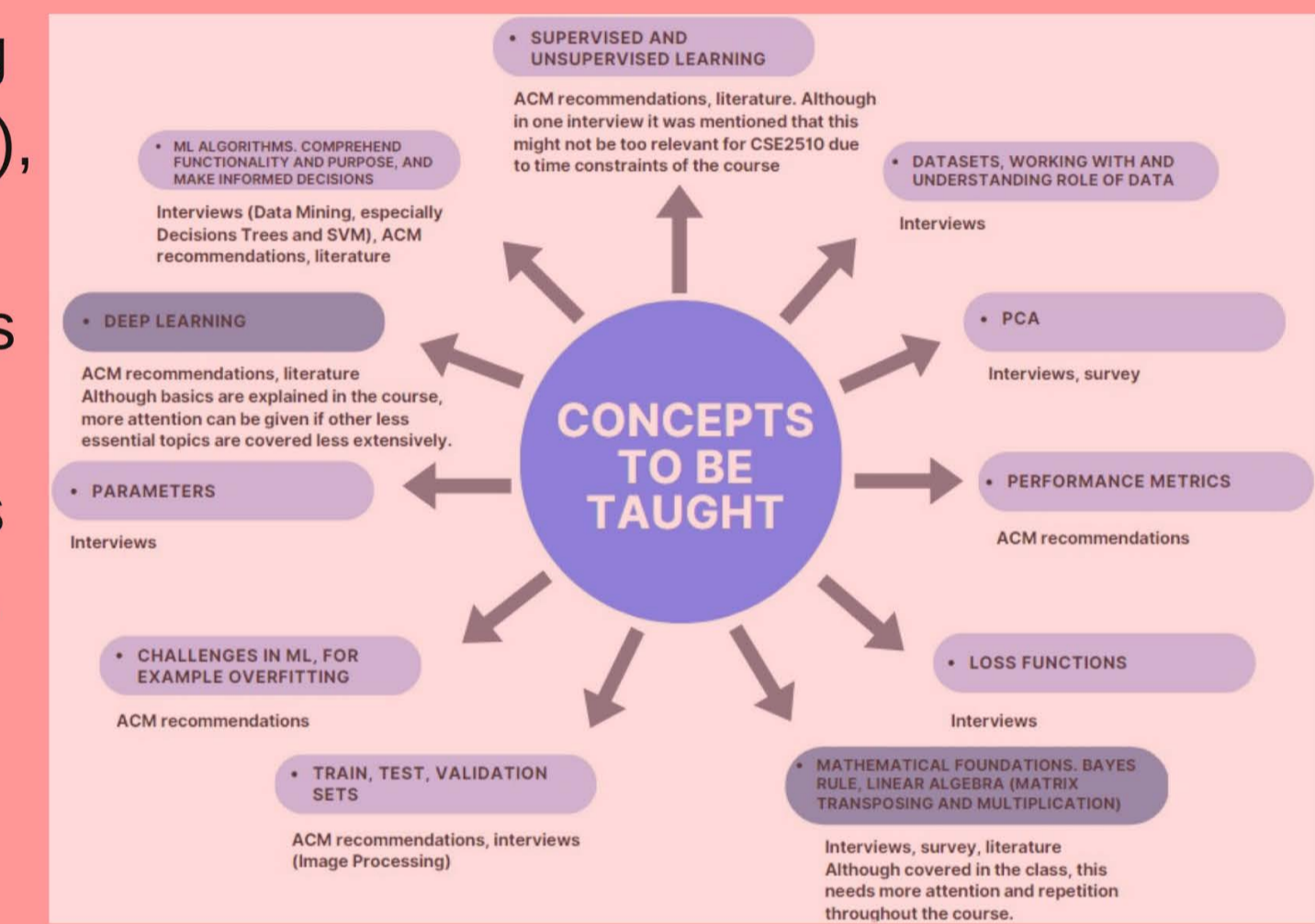
5. Recommendations

- Homogeneity in the responses obtained, with no pronounced contradictory opinions. No glaring gaps identified in the content or structure of the course.
- More emphasis on importance of understanding mathematical foundations required in ML. CSE2510 should collaborate closely with Mathematics Department to help facilitate these mathematical courses in first-year program. Ensure students comprehend rationale behind taking math courses and thoroughly understand the concepts taught within them
- Synchronize efforts of teaching staff, forming a unified and focused approach towards delivering a concise and wellrounded ML course

4. Conclusion

- Current CSE2510 effectively teaches necessary concepts for preparing for subsequent courses
- Yet, limited mathematical foundations among students. Allocate more attention to assisting students in developing a solid mathematical foundation. Collaboration with first-year mathematics courses