AIM@VET-Inspired University Level Education Strategies for Teaching Comp-Uter Vision and Biometrics

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Computer vision and biometrics are increasingly important in many AI-driven applications, yet teaching these fields poses challenges in balancing theory and hands-on practice. This paper presents a structured approach implemented for the technical skills course at the Faculty of Computer and Information Science, University of Ljubljana, designed for Computer Science students. The course integrates guided Jupyter Notebook exercises while allowing students to complete coding tasks while leaning on AI assistance. In-person presentations and discussions reinforce understanding by requiring students to explain their implementations and problem-solving strategies. The 15-week curriculum progresses from basic image processing to deep learning-based biometric recognition. Teaching materials are derived from the AIM@VET EU project, which focuses on adapting AI education to labor market needs, but adapted here for university students. We hope that AI-assisted, structured coding exercises combined with interactive discussions will enhance engagement and comprehension, better preparing students for a variety of applications in computer vision and biometrics.

Keywords:
omputer vision,
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AIM@VET IZOBRAŽEVALNI MATERIALI ZA UNIVERZITETNO POUČEVANJE RAČUNALNIŠKEGA VIDA IN BIOMETRIJE

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Ključne besede:
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globoko učenje,
AIM@VET

Računalniški vid in biometrija postajata vse pomembnejša na različnih področjih umetne inteligence, vendar njuno poučevanje predstavlja izziv pri uravnoteženju teorije in praktičnega dela. Ta članek predstavlja strukturiran pristop, uporabljen za predmet tehničnih veščin na Fakulteti za računalništvo in informatiko Univerze v Ljubljani, namenjen študentom računalništva. Predmet vključuje vodene vaje v Jupyter Notebookih in študentom omogoča reševanje programskih nalog s pomočjo raznih inteligentnih orodij. Razumevanje snovi je dodatno okrepljeno s predstavitvami in razpravami, kjer študenti predstavijo svoje rešitve in reševanje problemov. Predmet v 15 tednih napreduje od osnovnega procesiranja slik do biometričnega prepoznavanja z globokim učenjem. Učni materiali izhajajo iz evropskega projekta AIM@VET, ki se osredotoča na prilagajanje izobraževanja o umetni inteligenci potrebam trga dela, tu pa so prilagojeni za univerzitetne študente. Upamo, da naloge podprte z umetno inteligenco in interaktivne razprave izboljšujejo angažiranost in razumevanje ter študente bolje pripravljajo na različna področja računalniškega vida in biometrije.

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1 Introduction

Computer vision and biometrics are rapidly advancing fields with widespread applications in security, healthcare, autonomous systems, and human-computer interaction. As these technologies continue to shape various industries, it is essential for university students to gain both a strong theoretical foundation and practical experience. However, teaching these subjects at the university level presents several challenges. Many core algorithms rely on complex mathematical concepts and deep learning techniques, which can be difficult for students to grasp without proper guidance and hands-on experience. Furthermore, computer vision and biometrics demand significant computational resources, often requiring high-performance GPUs and large datasets to train and evaluate models effectively. This creates additional barriers for students who may not have access to advanced hardware. Additionally, the interdisciplinary nature of these fields means that students must also understand their connections to artificial intelligence, cybersecurity, and ethical considerations, making it necessary to design a curriculum that balances multiple disciplines (Jiang, 2023; Wu, 2023).

To address these challenges, we have developed educational materials tailored specifically for university-level Computer Science students. The materials are based on parts of the ongoing EU project AIM@VET (Artificial Intelligence Modules for Vocational Education and Training) (AIM@VET 2025), which focuses on developing learning modules to adapt Vocational Education and Training to the needs of the labor market, with a particular emphasis on AI. The project involves six partners from Spain, Portugal, and Slovenia. In the Slovenian branch, the University of Ljubljana (UL) and School Center Velenje (SCV) serve as contributing partners, focusing on the computer vision aspect of AI. The topics covered include capturing and curating unbiased data, detection and segmentation, and tracking and recognition. This closely aligns with the needs of the developed university-level educational materials, albeit at a more advanced level. Furthermore, during the development of the AIM@VET materials, some parts were rejected or modified due to their excessive complexity (Emeršič, 2023; Kirn 2024; Emeršič, 2024; Emrešič, 2025a; Emeršič 2025b); these were instead incorporated into the proposed university-level materials.

The teaching materials will be used in the course "Technical Skills 2" at the Faculty of Computer and Information Science, University of Ljubljana. The course will introduce students to fundamental concepts of computer vision, with a strong focus on biometrics, and will incorporate deep learning techniques alongside extensive hands-on activities. The curriculum is designed to bridge the gap between theory and practice by integrating modern frameworks such as OpenCV and PyTorch, enabling students to build real-world biometric systems, including detection, segmentation and recognition models. Given the increasing demand for these skills, the course emphasizes project-based learning, encouraging students to engage with real datasets, implementing machine learning models, and optimize biometric authentication methods. The Technical Skills course will, hopefully, not only prepare students for careers in AI-driven fields but also ensure they develop problem-solving abilities applicable across multiple domains. This paper summarized the educational approaches implemented in the course and the solutions adopted to enhance the learning experience for students specializing in computer vision and biometrics.

2 Educational Approaches

2.1 Traditional vs. Modern Teaching Methods

Teaching computer vision and biometrics requires a combination of traditional theoretical instruction and modern, hands-on learning techniques. Traditional methods, such as textbook learning and lectures, provide a necessary foundation for understanding the mathematical principles and algorithms underlying computer vision. These include concepts like convolution, feature extraction, and statistical learning, which are essential for understanding advanced AI techniques. However, when presented in isolation, these methods can be abstract and disengaging for students, especially in a field that relies heavily on practical applications (Ashwin, 2023; Jeon, 2023; Abdrakhmanov, 2024).

To bridge this gap, modern teaching approaches incorporate interactive coding exercises, real-world applications, and AI-driven tools to enhance engagement. Instead of focusing solely on theoretical derivations, students actively experiment with image processing, biometric recognition, and deep learning models in programming environments. The integration of frameworks like OpenCV, TensorFlow, and PyTorch allows students to visualize and manipulate real-world data, improving their understanding of key concepts. This hands-on approach ensures that students not only grasp theoretical principles but also develop skills applicable in real-world industry scenarios.

2.2 Hands-On Learning and AI Assistance

To ensure practical engagement, the course follows a structured hands-on learning approach, where students work with pre-prepared Jupyter scripts that contain partially implemented code. Students are required to fill in missing parts, apply learned concepts, and experiment with different methods to complete tasks. This structured guidance helps them progressively build confidence in implementing complex algorithms while still being encouraged to think critically and experiment with solutions rather than just following instructions.

Another feature of this course is the integration of modern AI tools, such as ChatGPT and other large language models (LLMs), into the learning process. Students are encouraged to use these tools to troubleshoot code, generate explanations, and explore alternative solutions. However, reliance on LLM-generated content is not the final step—students must present and discuss their work in person, explaining their approach, reasoning, and any issues encountered. This ensures they fully understand the concepts rather than blindly following AI-generated solutions.

2.3 Assessment Strategies

To ensure that students acquire a balanced mix of theoretical understanding and practical skills, multiple assessment methods will be employed:

- Exams – Evaluate foundational knowledge, including mathematical concepts and algorithmic principles.
- Practical Assignments – Small coding exercises where students complete Jupyter Notebook tasks by implementing missing functionality.
- Final Projects – Require students to apply their knowledge to develop fully functional biometric systems.
- In-Person Presentations & Discussions – Students must present their solutions, explain their decision-making process, and discuss challenges they

encountered. This encourages critical thinking and ensures they understand the material beyond simply writing functional code.

These assessments ensure that students develop both conceptual understanding and hands-on expertise in computer vision and biometrics, while also improving their ability to critically evaluate AI-generated outputs.

3 Challenges and Solutions

3.1 Mathematical and Algorithmic Complexity

One of the primary challenges in teaching computer vision and biometrics is the complexity of the underlying mathematics. Many students struggle with concepts such as convolution, eigenvalues, and optimization techniques, which are fundamental to image processing and deep learning. To address this, the course incorporates interactive visualizations and step-by-step coding exercises that allow students to see how these mathematical concepts translate into real-world applications. Additionally, simplifying explanations before introducing complex equations helps students gradually build a solid understanding.

3.2 Hardware & Infrastructure Needs

Training deep learning models for computer vision and biometric analysis typically requires high-performance GPUs and large datasets, which can be a challenge for students working on personal machines. To mitigate this, the course provides access to cloud-based computing platforms such as Google Colab and AWS, allowing students to run deep learning experiments without requiring expensive hardware. Additionally, the use of pre-trained models helps reduce computational costs while still allowing students to experiment with biometric recognition tasks.

3.3 Interdisciplinary Nature

Computer vision and biometrics intersect with multiple disciplines, including AI, cybersecurity, ethics, and statistics, which can make it difficult for students to grasp the full scope of the field. The course addresses this by integrating interdisciplinary modules that encourage students to explore real-world applications. For example, students will study biometric authentication systems from both a technical and ethical perspective, learning about issues such as bias in biometric algorithms and security vulnerabilities in facial recognition systems.

3.4 Industry Relevance & Employability

Employers in AI-driven industries prioritize practical implementation skills over theoretical knowledge alone. Many university courses fail to equip students with the hands-on experience necessary for careers in computer vision and biometrics. To bridge this gap, the course includes industry-relevant projects, guest lectures from experts in the field, and opportunities for students to contribute to open-source projects. Additionally, by requiring students to present and defend their work in discussions, the course strengthens their ability to explain technical concepts, a skill that is highly valued in both industry and academia.

4 The Proposed Teaching Materials

The proposed course, "Technical Skills 2", at the Faculty of Computer and Information Science, University of Ljubljana, follows a structured 15-week plan, covering key topics in computer vision and biometrics. The teaching materials have been developed to align with industry needs while ensuring that students gain both foundational and advanced knowledge in the field. The course follows a progressive structure, where students begin with basic image processing and gradually advance to deep learning-based biometric recognition. An example of a Jupyter script with solutions is shown in Figure 1.

Course Breakdown:

- Weeks 1–2: Introduction to computer vision fundamentals, image manipulation, and ethics in AI. Students learn how to import, process, and enhance images while addressing issues like bias in biometric datasets.
- Weeks 3–5: Students explore biometric modalities (face, fingerprints, gait, voice, etc.), implement object detection using classical methods, and transition to deep learning-based detection models like YOLO and Fast R-CNN.

- Weeks 6–7: Introduction to semantic segmentation, including U-Net and Mask R-CNN, applied to biometric data.
- Weeks 8–10: Object tracking techniques and advanced human recognition methods such as gait and action recognition.
- Weeks 11–12: Feature extraction and pattern analysis methods for biometric authentication.
- Weeks 13–14: Deep learning approaches for biometric recognition using ResNet, EfficientNet, and ViT.
- Week 15: Integration of individual components into a complete biometric recognition pipeline, including real-world use cases.

Figure 1: An example of teaching material in the form of a Jupyter script. On the left, a framework for completion; on the right, a display of the completed solution.
Source: Own work.

The educational materials draw upon the AIM@VET EU project, which focuses on adapting AI education to meet labor market demands. While AIM@VET primarily targets vocational education, some more advanced content that was deemed too complex for vocational training has been adapted for university-level instruction

(Emeršič, 2023; Kirn, 2024). These materials include advanced deep learning models, biometric security case studies, and practical applications in AI ethics.

By structuring the course around hands-on activities and real-world applications, students gain the skills necessary to develop industry-grade biometric recognition systems. The combination of theoretical lectures, structured coding exercises, LLM-assisted problem-solving, and in-person discussions ensures that graduates are well-equipped for careers in AI, cybersecurity, and biometric research.

5 Conclusion

This paper demonstrates a structured, hands-on approach to teaching computer vision and biometrics, combined with AI-assisted learning and interactive discussions. Preliminary findings during AIM@VET project, show that this enhances student engagement and comprehension. Materials adapted and implemented for the course "Technical Skills 2" at the Faculty of Computer and Information Science, University of Ljubljana, the methodology integrates guided Jupyter Notebook exercises, biometric datasets, and modern LLMs, such as OpenAI's, Meta's and DeepSeek's derivatives, enabling students to complete coding tasks while critically evaluating AI-generated solutions. The requirement for in-person presentations and discussions further reinforces understanding by encouraging students to articulate their reasoning and problem-solving strategies.

The 15-week curriculum, covering topics from basic image processing to deep learning-based biometric recognition, provides students with both theoretical foundations and industry-relevant practical skills. Challenges such as mathematical complexity and computational resource limitations are addressed through cloud-based computing environments and interdisciplinary project design. Teaching materials, partially derived from the AIM@VET EU project, align with industry needs and ensure that students gain practical experience applicable to real-world biometric and AI-driven applications.

Findings during AIM@VET suggest that combining structured coding exercises, AI tools, and interactive discussions fosters a deeper understanding of computer vision and biometrics while preparing students for their careers in AI. Future work could explore further AI-driven enhancements in education, such as automated feedback systems during learning, adaptive learning pathways, and deeper industry collaborations, to continue improving the effectiveness of AI education.

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