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DEVELOPMENT AND ASSEMBLING OF TEXTILE PRODUCTS

Development of a transdisciplinary education concept to prepare textile technology students for dealing with AI

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ABSTRACT

A basic understanding of the mechanisms and implications of the use of Artificial intelligence (AI) is crucial to effectively implement AI in business and society. To achieve this goal, the research project described here aims to provide students from different disciplines with practical AI knowledge. Instead of focusing on traditional teaching approaches, students work together on transdisciplinary and interdisciplinary projects. The basis here is provided by department-specific application scenarios. Supported by learning nuggets, expert lectures and an accessible software infrastructure, students thus gain easy access to AI topics. The goal in the Faculty of Textile and Clothing Technology is to train specialists in the use of AI in the textile process chain. Students will learn how to classify image data of fibers based on a practical example. Among other things, they will generate a data set for a neural network and work closely with computer science students to implement it. The focus is on enabling students to apply AI independently and thus create the basis for new innovative ideas in industry.

Keywords
artificial intelligence,
artificial neural network,
transdisciplinary project,
education concept,
image classification,
fiber analysis

1 Introduction

In order to use artificial intelligence profitably in business and society, well-trained specialists are needed who can actively shape technological and social change across disciplines in various application areas. This also requires a fundamental social understanding of the mechanisms and implications of AI [1,2].

AI-related competences are not only required in computer science-related courses of study, but also application areas and disciplines which are not related to computer science require a fundamental social understanding of the benefits and possible applications of AI. In order to cover as many areas of application as possible, this project was launched, in which different faculties collaborate and work together on the implementation of AI in their curricula. The faculties included in the project are

- Electrical Engineering and Computer Science
- Food, Nutrition and Hospitality Sciences
- Applied Social Sciences
- Textile and Clothing Technology
- Health Care

The faculties are supported by the university's didactics team to implement new educational approaches fitting to the content of the individual lectures.

2 Method

The various complementary teaching-learning formats, which are based on each other and developed jointly by the actors in this project, are combined into a blended learning concept.

The central element of the project are transdisciplinary projects in which students from different degree programs work together on a common task. In degree programs in which no compulsory projects have been planned so far, students can alternatively participate via the compulsory elective area.

Figure 1 shows the structure of the planned teaching-learning concept.

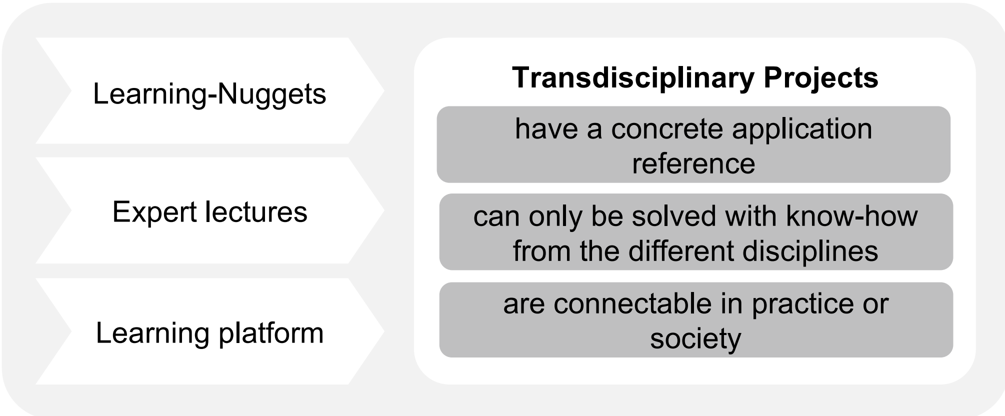

Fig. 1 Planned teaching-learning concept.

The following minimum didactic standards are used as a basis for the planned transdisciplinary projects:

- the project topics have a concrete application reference
- the project problem can only be solved on basis of the knowledge from the various disciplines
- the solutions are fundamentally connectable in practice or society, for example, because the project topics were provided by external parties

In transdisciplinary projects, students from culturally heterogeneous fields of study jointly apply AI in such a way that a given practice-relevant problem is solved through these transdisciplinary projects, students gain experience in interdisciplinary cooperation and thus experience that the solution to problems from everyday life and work does not stop at disciplinary boundaries, but solutions can only be found across disciplines. This enables a concrete insight into a central challenge of modern knowledge societies, which is characterized by highly emergent systems, organizations and situations [3]. In addition, the students also deepen competences in their own discipline by being challenged to communicate their subject-related concepts, working practices and methods in an intersubjectivity comprehensible way [4-6] to other people who do not have an affinity with the subject [7,8].

Besides the transdisciplinary projects, learning-nuggets, expert lectures and a learning platform are part of the teaching-learning concept. The complementary teaching-learning units (learning nuggets) are targeted at specific groups and are based on the needs and knowledge levels of the different student groups. The underlying question is which complementary basic knowledge the respective project participants need in order to be able to work efficiently and effectively on a project with students from the other disciplines. Accompanying expert lectures will provide impulses from society, business and industry on AI applications. These presentations are bundled in a group event and offer an opportunity to connect the work in the projects and their results to professional and societal practice (translation).

Specifically, within the framework of this project, various transdisciplinary project events are to be designed, repeatedly carried out and evaluated in the four application areas (faculty food, nutrition and hospitality sciences; faculty applied social sciences; faculty textile and clothing technology; faculty health care). Formats are planned for bachelor's and master's students from the application areas and from the computer science degree programs. In addition, there will be a compact AI course for bachelor's students from the application areas and a non-technical elective module on social aspects of AI for computer science students [7,8].

The faculty of textile and clothing technology will use the existing potentials in order to be able to guarantee an important basis for a sustainable textile industry. The aim is to train appropriate textile specialists who, with newly acquired skills, are able to implement new AI-based technological developments in the textile process chain [9]. It is important to emphasize at this point that the students should not become experts for the development of an AI. But the knowledge and the practical relevance should help to deal with AI in textile process chains but also find new impulses for the implementation of an AI.

Among other things, the students will be trained through a concrete use case of AI in textile technology. This use case is based on a classification of image data. The students will both create data for AI, through textile-specific analysis methods, and work together with students from the Department of Computer Science on an implementation of AI. The goal of the course is the independent application of artificial intelligence. The mapped and practically learned path of AI development then paves the way for new idea creation in practical applications in the industry.

The teaching concept for the classification of image data is based on the application example of the analysis of fiber material. The fiber analysis is a suitable core element for the new learning module, as it addresses a very broad target group of students within the faculty. Each student carries out the fiber analysis manually – independently of the project – in a practical course in the first semester of the bachelor's degree programs. Thus, a broad target group of students from all study programs is reached. In addition, the application of the fiber analysis offers a high practical component, which provides a good basis for generating a database and thus serves as an easily understandable example for the application of AI. This ensures that students get an easy start in hands-on experience with an AI and learn how AI can be used in the workplace.

Figure 2 compares the existing process flow of unknown fiber material analysis without AI (top) with the process-optimized flow by integrating AI (bottom). Natural fibers can be distinguished by their cross-section and longitudinal view. In order to do so, the unknown fibers must first be prepared. Afterwards, both the longitudinal views and the cross-sections can be observed under a microscope. By comparing the cross-sections and longitudinal views with literature or through expert knowledge, the fiber material of the unknown fiber can be determined. The comparison with literature requires time and expertise. The figure shows that the integration of AI offers advantages with regard to time and required expertise. By integrating AI, unknown fibers can be determined more quickly and no specialized knowledge is required. The images taken with the microscope are fed into an artificial neural network which recognizes the fiber type based on image features through previous training [10-14].

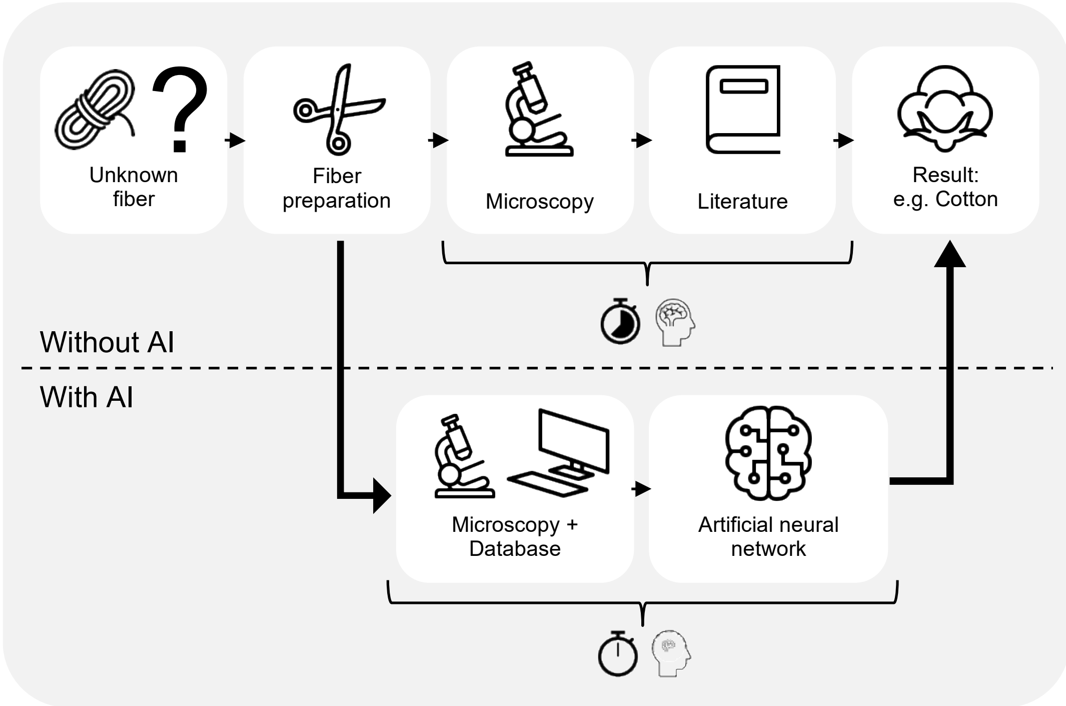

Fig. 2 Fiber analysis process.

By means of this AI image evaluation, it can be shown which advantages the use of AI can have.

With regard to the overall project, the gained knowledge and results can be made available in databases and networks in order to facilitate access for other interested parties and to enable a spreading of the topic. Synergies could be used through cooperation with other institutions and companies to further expand and optimize the application possibilities of AI in the textile industry. Possible cooperation partners for transdisciplinary projects are, for example, companies from the textile industry or research institutions that are involved in the development of AI methods.

In summary, students learn both interdisciplinary and transdisciplinary references related to AI for textile process chains; in this case fiber analysis. The handling of AI is learned and the students get a practical reference to AI. This is to ensure that the students master modern working methods and can find new impulses for further AI implementation.

3 Development and test of lecture concept

Figure 3 shows the structure of the planned lecture concept of the faculty of textile and clothing technology. As mentioned in section 2, the lecture concept focuses on the application example of fiber analysis and how AI can improve this process. The planned lecture will be offered to students as an elective course in the third and fifth bachelor's semester.

The overall goal of the teaching concept is to provide students who have no reference to AI with a reference and make them fit for the practice and handling of AI for their own field of study. Specifically for the faculty of textile and clothing technology, students receive a practical reference to a topic through the fiber analysis with the help of an AI, which was otherwise not available in the format in the entire course offering. Generating a dataset for image data of natural fibers, such as wool, silk, flax, and cotton, and developing an AI that is trained on natural fibers serves only as a means to an end.

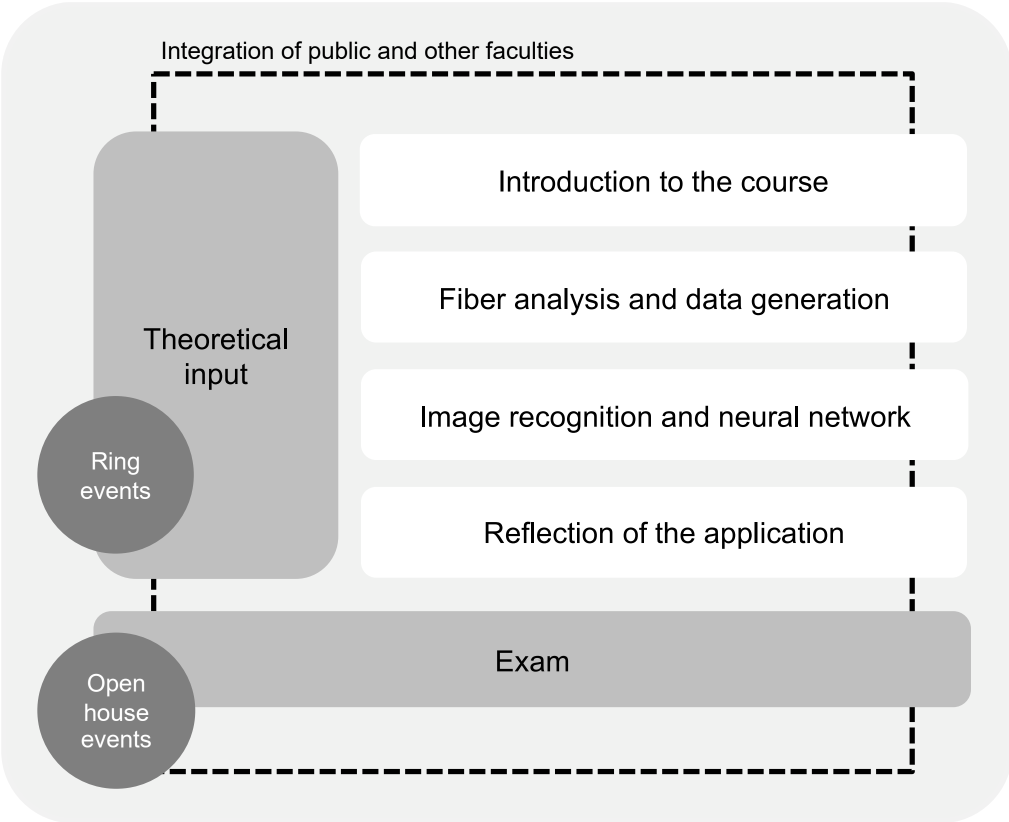

Fig. 3 Lecture concept of the faculty of textile and clothing technology.

The one-semester course is divided into four lecture units plus an examination. Within the four units, students constantly receive new theoretical input. The course concept starts with an introduction to the course, to provide students with an overview of the topic of AI. Afterwards, the practical work starts, in which the students have to carry out the fiber analysis and generate images of the cross-sections as well as the longitudinal views. The third part focuses on image recognition and neural networks. This part includes aspects such as how AI-based image classification works, which features are recognized as well as the development and testing of an AI image classification tool for the classification of fiber material. The last part is about the evaluation of the AI image classification tool with regard to how successful the classification of the natural fibers turned out.

In order to ensure the interdisciplinary and transdisciplinary focus of the project, the other faculties as well as the public in the form of companies or research institutes can be integrated into the course at various points. In particular, connections to faculty of electrical engineering and computer science with regard to the joint development of an artificial neural network for the automated fiber analysis are advantageous. Furthermore, the theoretical input can be supplemented by participating in ring events. Additionally, the performance in the examination can be opened up to the public as open house events, for example in the form of a presentation of the project results.

In the summer semester 2023, the developed course of the faculty of textile and clothing technology was piloted as an elective course. The course was held in a shortened version of the planned lecture concept. Thus, the course consisted of four parts (Fig. 4).

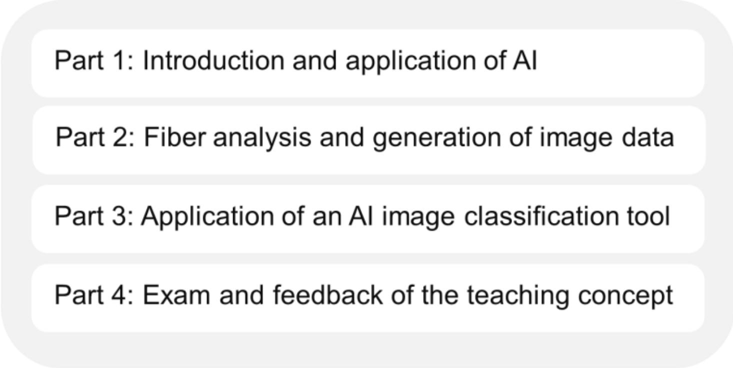

Fig. 4 Concept of the piloted elective course.

Within the first part, the students learned the basics of artificial intelligence. Afterwards, each student had to research an area of AI of their choice on his/her own and present their chosen topic to their fellow students. During this task the students should also evaluate for which scenarios in the textile production chain an AI application could be helpful. Different AI applications were investigated and presented, e.g. text based AI, image generating AI and process analysis AI.

In the second part of the course, the application example of fiber analysis was presented. To train AI, data is required (in this case image data) [15-18]. Therefore, the students had to generate image data in the first step. For this purpose, the samples of the longitudinal view and cross-section had to be prepared and images of the fibers had to be taken with the help of a microscope.

After the image data was generated and stored in an appropriate database structure, these images were processed in the third part to enable an AI image classification tool to easily recognize the corresponding fiber features. Subsequently, the processed images were inserted into an already existing image classification tool in order to test which fiber features are recognized. As this is not a fiber-trained classification tool, it has not yet been possible to automatically determine the fiber material using AI but built a foundation of knowledge, which characteristics the algorithms will focus on, and with this define the basis of the correct classification algorithm.

Finally, in the submission of a term paper (exam), an additional evaluation sheet was prepared and required of the students to fill it out in detail. This evaluation sheet contained questions about the structure, organization, and presentation of the individual contents in the course, which were to be evaluated by the students. We have already forwarded this evaluation form to our didactics department, so that we can create an improved concept for practice from the resume.

The evaluation of the questionnaire on the concept and content of the course showed that the students were very interested in the topic during the course. Artificial intelligence has become more tangible for the students and is no longer a foreign concept. The concept was accepted and even desired by the students, in this case to work more intensively with the Department of Computer Science and to realize further projects. It also showed that the students would have liked to learn more about the development and implementation (programming) of AI.

4 First results

Within the pilot lecture, a first data set of cross-sections and longitudinal views of the natural fibers cotton, wool, flax and silk was generated. As part of the course, microscope images of the cross-sections and longitudinal views of the four different natural fibers were taken.

Figure 5 shows images of wool, as an example. The two upper images show photos of the cross-section of wool fibers and the two lower images show the longitudinal view of a wool fiber. The pictures on the left-hand side (grey) are the pictures of the fibers obtained with the microscope. After the images were taken, they were inserted into an already existing AI image classification tool, which is freely available on the internet. The images on the right-hand side (orange) show the resulting output of this AI image classification tool. The outlines of the fibers and some relevant contours can already be recognized by the AI image classification tool. Each type of natural fiber has different characteristics by which the fiber can be identified. For example, the longitudinal view of wool has a scale-like structure and a round shape in cross-section [10,11].

The pictures of the AI image classification tool (orange) show that the round shape contour of the cross-sections of the wool fibers are recognized by the AI. In the longitudinal view, the AI tool only recognizes the outer edges of the fiber and not the inner scale structure, which is the typical feature of the longitudinal view of wool fibers and necessary for distinguishing the fiber from other natural fibers. Thus, it can be concluded that the already existing AI image classification tool is good to get a first general impression of what AI is able to identify in an image. However, this specific AI tool is not suitable for the precise classification of natural fibers. An individually trained AI tool based on fiber datasets has to be built up to get precise results for this application.

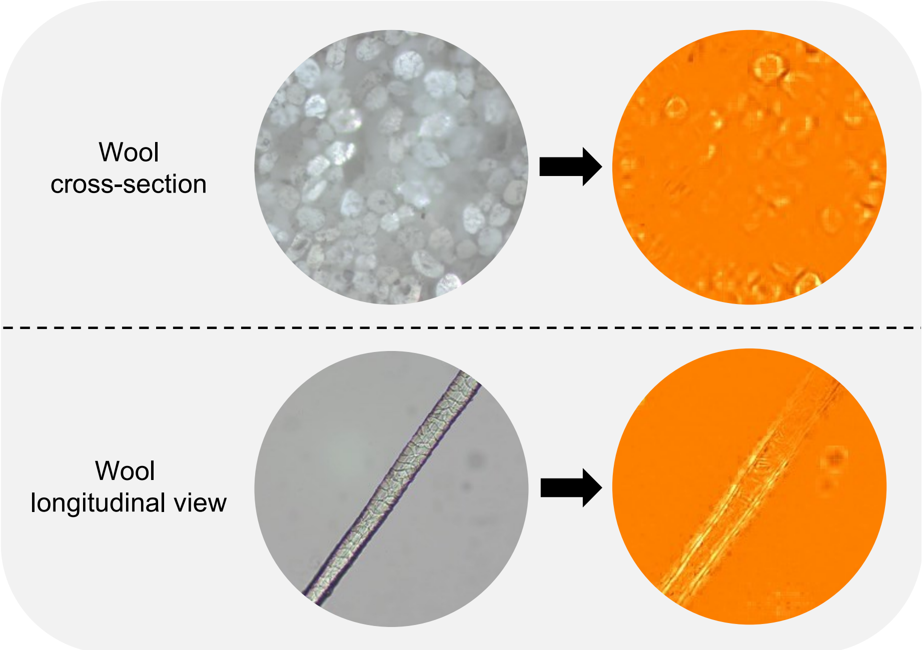

Fig. 5 Microscope images of wool fibers.

5 Future vision

In the further progress of this project, additional microscope images of the cross-sections and longitudinal views of the natural fibers will be generated with the aim of creating a dataset of image material. These image data shall be stored in a structured manner in a database specially designed for this purpose. The required database will also be developed within this project.

As the evaluation of the first results of the microscope images has shown, it is not sufficient to rely on an already existing AI image classification tool for the classification of natural fibers. Therefore, within the project, an AI image classification tool shall be developed specifically for the classification of natural fibers on the basis of their cross-sections and longitudinal views. The learning of this AI tool will be done through the process of supervised learning. This means that datasets of labelled data are necessary to train the AI tool [15,16]. These labeled image data will be collected in the previously developed database.

Author Contributions

All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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