DICE-EV0003 Smart Wearables II
Spring 2024

Aalto University
School of Electrical
Engineering

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Self-Introduction

- **Yu Xiao**
- **Associate Professor at Aalto/ELEC**
- **Doctoral degree in Computer Science, 2012**
- **Research interests:** wearable sensing, augmented/virtual reality, edge computing. More information from *mobilecloud.aalto.fi*
- **Courses I have taught since 2014**
    - Smart Wearables, Internet protocols, Basic principles in networking, Energy-efficient mobile computing, AR-based cognitive assistance systems development, Mobile cloud computing

- **Course Assistant: Tim Moesgen**
- **Doctoral student working on wearable haptics**
- **M.A. from Aalto/ARTS**

- **Course arrangements**
- **Discussion**
  - How to form a group?
  - How to choose a topic?
  - How to track the progress of project work?
  - How to assess project work?

DICE-EV0003

- **6 ECTS (Period III & IV)**
- **Multidisciplinary course for master and doctoral students**
- **Smart Wearables II:**
  - Emerging technologies and applications
  - Design process and approaches
  - Theory + practice

Smart Wearables

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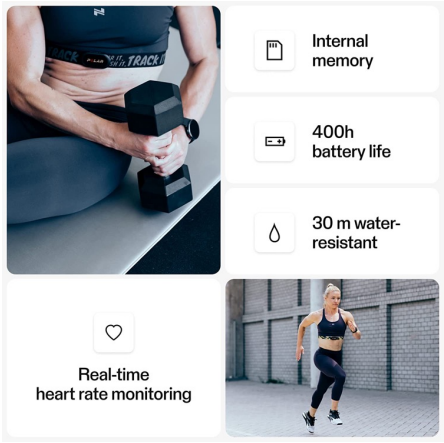
Source: Oura

Source: Fitbit



Source: Polar

Source: Myontec

Source: Adidas

Source: MIT

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Source: Apple

Source: https://haptx.com/

Source: https://teslasuit.io/

- **DICE-EV0002 Smart Wearables covers basics of smart textiles (e-textiles) https://mycourses.aalto.fi/course/view.php?id=41448**
- **A textile is smart when it reacts to changes in the environment.**
  - Stimuli: mechanical, optical, thermal, chemical, etc.
  - Response: change in materials properties, color, electrical outputs, etc.

- You can find an interesting talk about smart textiles from YouTube: **https://www.youtube.com/watch?v=50oCpt3ckB4**
- Ates, H.C., Nguyen, P.Q., Gonzalez-Macia, L. et al. **End-to-end design of wearable sensors.** Nat Rev Mater 7, 887–907 (2022). https://doi.org/10.1038/s41578-022-00460-x
- Ismar E, Kurşun Bahadir S, Kalaoglu F, Koncar V. **Futuristic Clothes: Electronic Textiles and Wearable Technologies**. Glob Chall. 2020 Mar 18;4(7):1900092. doi: 10.1002/gch2.201900092. PMID: 32642074; PMCID: PMC7330505.

Expected Learning Outcomes

At the end of the course, students should be able to

1) Conduct a user-oriented ideation process and concept generation leading towards the creation of e-textile-based wearable systems.

2) Implement prototypes of smart wearables using advanced fabrication and/or machine learning techniques.

3) Conduct evaluation of system performance and user experience through user tests.

4) Improve team working skills in a multi-disciplinary setup.

Smart Wearables II

- **Invited talks (Period III)**
  - Biomaterials for smart textiles, design for sustainability
  - Advanced fabrication methods like weaving and printing
  - Emerging user interfaces for extended reality applications
  - Smart wearables for health and wellbeing
  - User-centered design: theories and practices

Schedule

Theme 1: Sustainability

12.1.2024 (Fri) 12.15-14.00 Design for sustainability in the context of smart textiles

17.1.2024 (Wed) 12.15-14.00 Biomaterials for smart textiles

19.1.2024 (Fri) 12.15-14.00 User-centered design for wearables

Theme 2: Advanced fabrication methods

24.1.2024 (Wed) 12.15-14.00 Printing

26.1.2024 (Fri) 12.15-14.00 Woven Structures

Theme 3: XR

31.1.2024 (Wed) 12.15-14.00. Wearable haptic interfaces for XR

2.2.2024 (Fri) 12.15-14.00. Invited lecture from KONE

Theme 4: Smart Wearables for Healthcare and Wellbeing

7.2.2024 (Wed) 12.15-14.00. Invited lecture from GE Healthcare Finland

9.2.2024 (Fri) 12.15-14.00 invited lecture from Myontec

- **You are expected to attend at least 80% of lectures (if not, make-up assignments are required) and to write a learning diary for each theme/module (in total 4 diaries)**
- **Workload wise:**
  - Invited lectures and learning diaries: 1 ECTS, Period III
  - Project work (3 – 4 students/group): 5 ECTS, Period III- IV

- Form groups (asap)
- Ideation (presentations of your project ideas on Feb 14)
- Prototyping
- Evaluation

(iterative process)

- Final presentations (incl. demonstration, Q&A) on April 3/March 27.

- **Propose your own project ideas related to smart wearables**
- **Attend the lectures and get inspired**
- **Be creative**

Example projects

Self-Powered Textile-based Pressure Sensors for Breath Monitoring

This project focuses on developing self-powered textile-based pressure sensors tailored for precise breath monitoring. The self-powered pressure sensors are designed to be seamlessly integrated into the wearable, ensuring comfort and unobtrusiveness for the user. As the user breathes, the sensors detect subtle pressure changes and translate them into meaningful data points, providing insights into respiratory rate, depth of breaths, and potentially even lung health indicators. The project explores materials with high sensitivity to pressure changes and leverages energy harvesting mechanisms to create an autonomous and sustainable solution for continuous breath monitoring.

Wearable Thermal Haptic Interfaces for Virtual Tourism

The objective is to enable users to not only see and hear virtual destinations but also feel the temperature changes and ambient sensations of the places they are virtually visiting. The wearable thermal haptic interfaces use advanced materials and heating elements strategically placed on human bodies to simulate the environmental temperatures of different locations. As users explore virtual destinations, they can sense the warmth of a tropical beach, the cool breeze of a mountain summit, or the chilly air of an ice cave through the wearable thermal haptic interfaces. The project involves a careful study of temperature variations in diverse geographical settings and incorporates machine learning algorithms to dynamically adjust the thermal feedback, creating a more immersive and multisensory virtual tourism experience.

Assessment

- **Learning diaries (max. 8 points)**
  - What you have learnd from the lectures
  - Questions you would like to ask
- **Individual essay (max. 2 points)**
  - Include personal reflections on the design process, lessons learned, and skills developed.
  - Consider what worked well, what could be improved, and what might be done differently in future projects.
- **Project work (max. 65 points): working diary + demo + presentations**

Evaluation criteria of project work

- **User-centered design (1 – 5) weight: 3**
  - How well did the team understand the target users, their needs, and the context of use? Were well-defined user personas created to guide the design process? Were the user study methdology appropriate? How well were the results of user studies utilized as feedback in the iterative design process?
- **Creativity (1 – 5) weight: 3**
  - Is the idea novel? Any creative use of materials and technologies?

- **Ability to transfer the concept into a production (1 – 5) weight: 4**
  - Did the final prototype achieve the design goals (e.g., functions, performance, usability, sustainability, etc.)?
- **Documentation and presentations (1 – 5), weight: 2**
  - Did the group document the design process properly? Did the group manage to clearly present the design, implementation and evaluation?
- **Effectiveness of teamwork (1 – 5), weight: 1**
  - How well each team member understand and fulfil their roles? Did the team members communicate and collaborative effectively?

Scoring Guidelines

- **1-2:** Poor - Significant shortcomings, lack of understanding, or inadequate effort.
- **3:** Fair - Basic understanding and effort, some areas needing improvement.
- **4:** Good - Above-average performance, with minor areas for improvement.
- **5:** Excellent - Outstanding performance, thorough understanding, and execution.

Grading

The final grade depends on the total amount of points you have collected from project work (max. 65 points) and other assignments (max. 10 points)

45 - 48 points: 1

49 - 52 points: 2

53 - 56 points: 3

57 - 60 points: 4

61 - 75 points: 5

Working Diary (what you may want to document)

1.Project Overview:

- Briefly describe the project's goals, objectives, and scope.
- Outline the target audience and user personas.

2.Project Timeline:

- Include a timeline or schedule with milestones and deadlines.
- Note any deviations or adjustments to the original timeline.

3.Research and Discovery:

- Document research methods and findings related to user needs, and existing solutions
- Note any insights gained from user interviews, surveys, or observations.

4. Conceptualization and Ideation:

- Capture brainstorming sessions and idea generation.
- Document initial sketches, mind maps, or concept diagrams.
- Record discussions and debates regarding design directions.

5. Prototyping and Iteration:

- Outline the prototyping process, including tools used and design decisions made.
- Document user testing sessions, noting feedback and areas for improvement.
- Describe iterations and refinements based on user feedback.

6. Technical Development:

- Detail the technical aspects of the project, such as coding, hardware integration, or software development.
- Note challenges encountered and their resolutions.
- Document any changes in technology or tools used.

7. Collaboration and Teamwork:

- Record team meetings, decisions, and collaboration efforts.
- Highlight contributions from team members and acknowledge teamwork.
- Note any conflicts or challenges within the team and how they were addressed.

8. Feedback and Evaluation:

- Document feedback received from stakeholders, mentors, or clients.
- Include reflections on the feedback and how it influenced design decisions.
- Evaluate the project against initial goals and objectives.

9. Challenges and Solutions:

- Detail challenges faced during the project and the strategies employed to overcome them.
- Document any unexpected issues and their resolutions.

10. Visuals and Design Artifacts:

- Include images, sketches, wireframes, prototypes, or any visual materials that represent the project's evolution.
- Attach relevant design files, screenshots, or multimedia elements.

11. Final Deliverables:

- List and describe the final deliverables.
- Reflect on how well the final outcome aligns with the initial project goals.

12. Next Steps:

- Outline any recommendations for future iterations or improvements.
- Suggest potential areas for further exploration or research.

- **How to form a group?**
  - Common interests
  - Complementary knowledge and skill sets

How to work in a team?

- Clearly define roles within the team, ensuring each member has a distinct responsibility.
- Schedule regular team meetings to discuss progress, challenges, and to ensure everyone is on the same page.
- Encourage the use of collaborative tools for project management, document sharing, and communication.
- Implement a peer-review system for team members to provide constructive feedback on each other's contributions.
- Incorporate team-building activities to foster a positive and collaborative team culture.

Support

- **We can provide**
  - Arduino
  - Textile materials
  - Electronic components (e.g., resistors, wires, breadboard, vibration motors, accelerometers)
- **Soldering stations available at Sähköpala (TUAS building)**
- **Equipment available in our lab (KIDE 1591)**
  - Heat press
  - Sewing machine
  - Knitting machine
  - Weaving machine (requires training in advance)

Other practicalities

- **Microsoft Teams group**
  - Ask questions, provide feedback, and share experience
- **MyCourses**
  - Check schedules and download course materials
  - Register groups
  - Report attendence
  - Submit assignments

Questions?