Personal thermal comfort modelling with implementation of smart technologies

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Introduction

There is a great perspective to achieve energy savings with implementation of the smart technologies in the buildings. The impact of the users is recognized as an important factor for the building performance efficiency [1]. In accordance with the new building paradigm, human needs are placed as the central point for energy optimization and user actions are integrated in building management processes [2]. Therefore, this work is focused towards investigation of personal thermal comfort conditions and development of methods for smart regulation of heating and cooling system based on the thermal comfort information of the occupants.

Description of the research problem

- Thermal environment conditions in the buildings are regulated through standards.
- Current "one size fit all" approach is found to be too general since it doesn't take into account individual differences of the occupants [3] which can lead to disproportion between the calculated and real energy consumption in the buildings i.e. irrational energy use due to overcooling or overheating [1].
- Better understanding of personal thermal comfort requirements through user-cetric thermal comfort models could provide both improved occupant satisfaction and energy efficiency.

Research methodology

The detection of users' personal parameters was approached in such a way that users wore smart bracelets during working hours and their physiological signals (skin temperature and heart rate) were monitored. Also, users were asked to fill out a questionnaire about their subjective evaluation of thermal comfort (thermal sensation vote) in the room in certain time intervals during the day. The main goal of the conducted experiments was to investigate the relationship between changes in skin temperature and heart rate of users in relation to their thermal comfort in the office space, including:

- Personal parameters of the users (heart rate, skin temperature, subjective evaluation, individual differences between subjects i.e. age, sex, BMI, clothing level)
- Environmental parameters (air temperature, relative humidity, CO_2)

The proposed approach could provide more precise evaluation of the personal thermal comfort where gained field data could be useful for modelling of the personal thermal comfort, as important basis for smart regulation of the building energy systems. The scheme for the proposed system is presented in the Figure A.

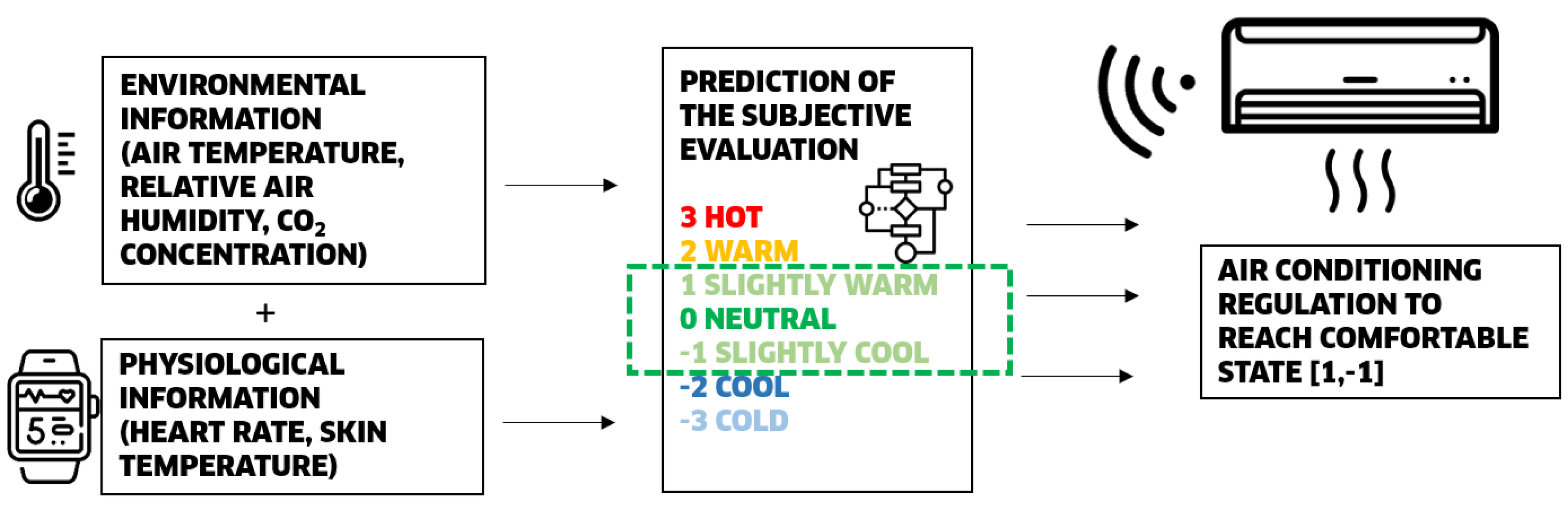

Figure A. Air conditioning regulation system based on the thermal comfort prediction of the user

Results

- The preliminary data processing was conducted on 12 users to gain insight into the general relationship of the skin temperature on the wrist and the air temperature in the observed office
- With the air temperature increase, the mean wrist skin temperature values from the users are also increasing in the range 19°C – 27°C
- Positive relationship between skin temperature (BTemp) and the room air temperature (AIRtemp) with correlation coefficient 0.77 for the female user (Figure B) and 0.76 for the male user (Figure B). For the male user, the skin temp and CO_2 level in the office also had a positive correlation (0,71).

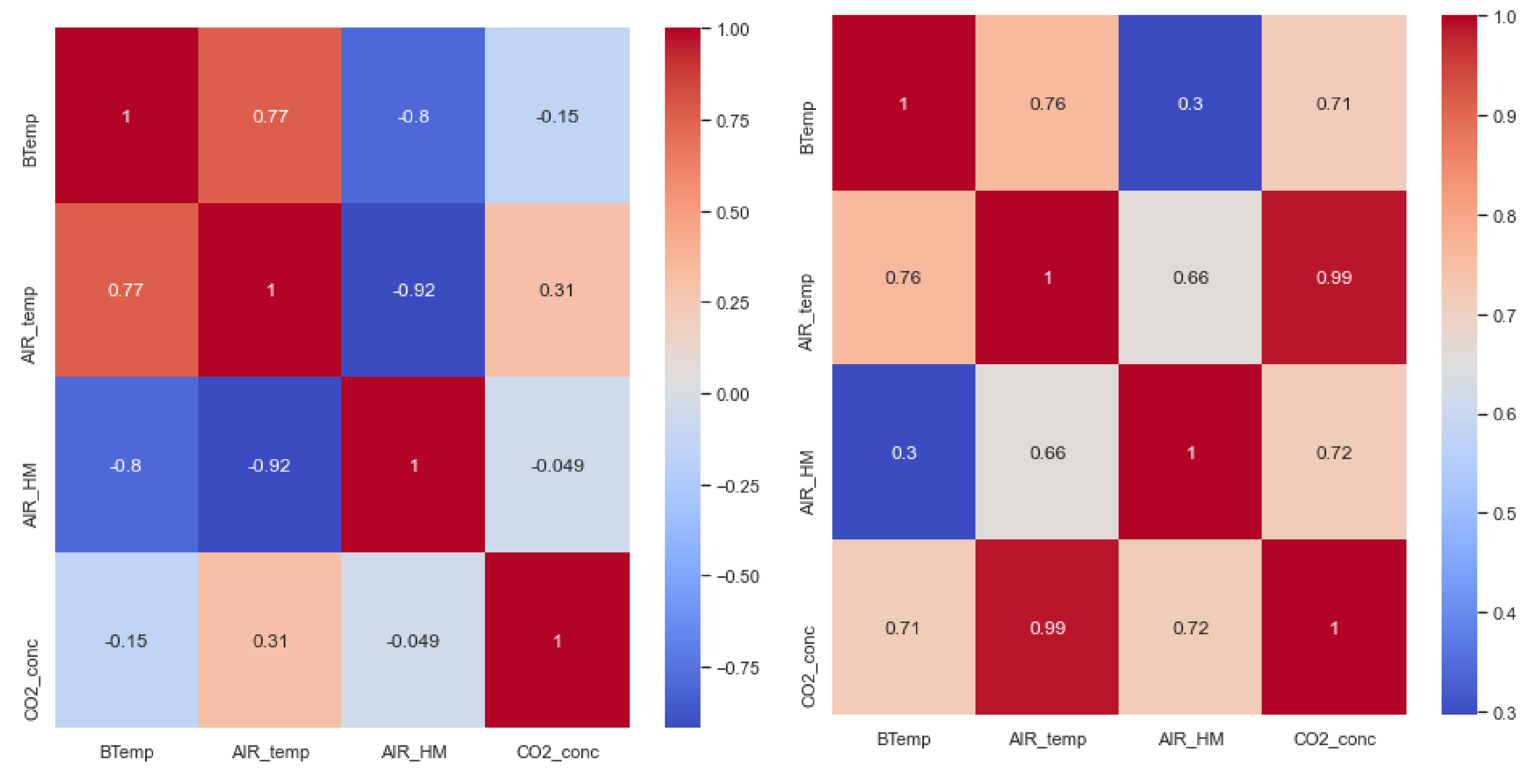

Figure B. Correlation matrix for the Female (left) and male user (right)

Conclusion

- When investigating wrist skin temperature from the individual users, it is noticed that the skin temperature has high positive correlation with the air temperature both for male and female users. These relations indorse the applicability of the low – cost measuring device (smart bracelet) for the personal thermal comfort detection.
- The impact of clothing level on the thermal comfort should be investigated more deeply in the future work.
- For the future work, applicability of machine learning algorithms for personal thermal comfort modelling should be conducted on the collected data from the experiment to predict user comfort with the physiological and environmental data as inputs. Finally, based on the prediction of the personal user's comfort, an algorithm for regulation of the split heat pump air conditioning system is planned to be developed. It could then be investigated if such approach has a perspective for application in smart buildings through intelligent management of heating and cooling systems and the energy efficiency of the proposed systems will be evaluated.

References

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Acknowledgement

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