ClimApp: A Mobile Application that Integrates Climate Forecast Data with Human Thermal Models

Henriette Steenhoff, s134869
Technical University of Denmark
Lyngby, 2800, Denmark
s134869@student.dtu.dk

ABSTRACT
This academic report describes the development and validation of

Author Keywords
climate; montioring; weather; forecast; mobile application

INTRODUCTION
Individualized and timely advice on appropriate actions in thermal climate stress is in strong demand. Such information will encourage protective strategies and reduce morbidity and mortality among vulnerable populations and safeguard exposed workers by supporting decision-making at individual and organizational levels. The overall objective of the present project is to develop an advanced ClimApp (mobile application) that integrates climate forecast data into human thermal models and combined with individual user characteristics and human physiology to provide a user-friendly and interactive mobile tool to improve decision-making for adaptation strategies when facing thermal climate challenges.[1]

This app is developed as a part of the European Research Association for Climate Services (ERA4CS) project, ClimApp. The full motivation for the project can be found on the project webpage.[1] This paper serves as the documentation of the work done to create the technical platform and basic initial functionality of the app. The work done so far is in no way portraying the full picture of the functionality that the app is expected to encompass at the project's end, rather a status on the work in progress.

The app is developed based on requirements agreed upon with the project consortium supervised by Jørn Toftum (DTU) and Lars Nybo (KU). As stated in the project description on which this paper is based: "The initial application prototype should be able to store user data needed for the thermal calculations, extract climate service data from a webservice (API), integrate GPS position for the single user and transform climate service data into individual thermal stress indices for the local micro climate."

[1]http://www.jpi-climate.eu/nl/25223441-ClimApp.html

Collaboration
The app is developed in collaboration between several European universities: The Technical University of Denmark (DTU), Copenhagen University (KU), Lund University (LU) and Vrije University (VU), where DTU is responsible for the technical platform and development of the app.

Parts of the application's user interface relies on the work made by Sara Egli (LU)[2], who has been conducting user tests related to the ClimApp interface as a special course at Lund University.

Existing work
The Hot Environment Assessment Tool (HEAT) by David Sauter[3]

OSHA NIOSH Heat Safety Tool (Android App)[4]

Furthermore, the apps *Heat Stress*[5] and *Program Heat stress lait*[6] deals with heat stress in live stock.

The Predicted Heat Strain Mobile Application (PHS)[7]

WeatherFX by Antikytherus[8] is available for iPhone devices for 0.99 USD in App Store. This is the closest thing research in the field of apps can get to the solution we are trying to develop. This app uses your location together with weather data from the nearest weather station to provide information about work/rest ratio and hydration for both the current weather situation and as a forecast for the next 5 days. For each day a color code (reen/yellow/red) is provided as indication of your heat stress level.

Problem
One of the main problems in the existing solutions is that they require a large amount of user input. Looking into i.e the PHS app, all parameters for calculations are required as input by the user, which is cumbersome in the long run and might make the user less inclined to use the app. Furthermore, this app is only looking into the predicted heat strain. If the user wanted information about either hydration or work/rest ratio she would need an additional app to provide this information, which requires more work from the user. This is why

the WeatherFX app without a doubt is the best alternative on the market right now. However, the app is still missing some functionality as it does not take the individual user into account (the BMI), it is not personalized which is what the ClimApp project aims at providing to give the best adaption strategies.

Target group

As a proof of concept, the target group will be outdoor construction workers. The app will then gradually be updated with new functionality in order to accommodate a broader range of professions. This has been chosen as construction workers are one of the groups higlihted in the scientific document[1].

Motivation

Solution

The solution is an Android-based prototype in Java. The application requires the following input from the user: age, height, weight, metric system, activity level. Furthermore the app gathers information from the Open Weather Map API for current weather data and a 5 day forcast as specified in the scientific document[1, p.4, l.8-13]. An exerpt from the scientific document is shown below:

The main elements, features and functions of the App are shown in Figure 1. The following data will be requested by the app.

1. Meteorology data: air temperature, wind speed, humidity and mean radiant temperature (cloud coverage if radiant temperature is not available). These data will be transformed to thermal stress at individual level with possibility to input local microclimate data.
2. User individual characteristics: age, gender, body weight and height (BMI), heat acclimatization.
3. Activity level (body metabolic heat production).
4. Clothing insulation (3-5 typical categories respectively in Heat-, Indoor- and Cold-Mode).

Figure 1. Specifications exerpt from scientific document stating the main functions of ClimApp.

Development

The prototype is written in Java. The code is made publicly available on Github[2] along with documentation of the different parts of the code in the associated wiki[3].

The technical platform

Installation

The app is developed for Android devices with API level 26 or higher. Currently, the app is only available on GitHub, assuming that you have Android Studio, a compatible device to run the app from and the knowledge of how to run (install) the app on your own device from Android Studio.

Contribution

The report is written in full by the author. The code written for the app is mainly developed by the author, with contributions from Jørn Toftum in regards to the WBGT model calculations and solar irradiation. Model limits is agreed upon with Lars Nybo.

[2]https://www.github.com/frksteenhoff/ClimApp
[3]https://www.github.com/frksteenhoff/ClimAppwiki

METHODS

This section addresses the methods used in order to validate the design of the app and maps out why the implementation process is different from the theoretical norm/cycle.

As this project is ordered by the European Union whether or not there is a need for this application has not been further investigated, but rather assumed necessary. A lot of the initial development have been based on the expert knowledge from the ClimApp partners, as they already have a proficient understanding of what information is needed, from a potential user, in order to perform the model calculations. This is one of the reasons why this project started out with prioritizing different requirements and implementation of functionality for user input rather than figuring out who the user is through questionnaires and research in order to define the user and their needs.

Users have been involved in validating the design of the app.

Assessment of functionality

Purpose:

Participants

Apparatus

Procedure

Design

RESULTS/DISCUSSION

CONCLUSION

Future work

Below the work that is in pipeline for the app both short and long term will be described. The short term work spans over the work done before starting user testing, whereas the long term work might either take a long time to implement or not be relevant before we have some more user feedback.

Short term

1. Add weather forecast (upcoming 5 days)
2. Include models for clothing, cold stress (IREQ)
3. Make available in Google Play
4. System driven notifications
5. Hydration model for recommended fluid intake

Long term

1. Clothing options (possibly from database)
2. Make it possible to create several profiles on one device
3. Create screen for manual input (if you are going somewhere without access to internet, make predictions up front)
4.

ACKNOWLEDGEMENTS

A special thanks to Jørn Toftum, Lars Nybo - supervisors from DTU and KU respectivley.

Kalev Kuklane for going through app screens and suggest corrections.

Furthermore, I thank CHI, PDC and CSCW volunteers, and all publications support and staff, who wrote and provided helpful comments on previous versions of this document. Some of the references cited in this paper are included for illustrative purposes only.

REFERENCES

1. X, "ClimApp Scientific Document," 2017. [Online]. Available: https://drive.google.com/file/d/0B0i5YWgFdLkQM2hXUGtoai03WTVKZzlCMU1mNm1XdzdGQzZZ/view?usp=sharing
2. S. Egli, "Design of ClimApp - A brief design suggestion for an application for individualized weather adaption strategies," 2018.
3. D. Sauter, "Hot Environment Assessment Tool (HEAT) User's Guide," 2012. [Online]. Available: http://www.arl.army.mil/arlreports/2012/ARL-MR-0809.pdf
4. United States Department of Labor, "Heat Safety Tool - Occupational Safety and Health Adminstration," 2011. [Online]. Available: https://www.osha.gov/heat/index.html
5. Centre for Mobile Education and Research, "Heat Stress – Apps in Google Play," 2013. [Online]. Available: https://play.google.com/store/apps/details?id=ca.uoguelph.cmer.heatstress
6. Phileo - Lesaffre Animal Care, "Program Heat stress lait – Apps in Google Play," 2017. [Online]. Available: https://play.google.com/store/apps/details?id=com.phileo.programheatstress
7. R. Di Corleto, "Predicted Heat Strain App," 2016. [Online]. Available: http://www.thethermalenvironment.com/the-predicted-heat-strain-mobile-application/
8. Antikytherus, "Weather FX." [Online]. Available: https://itunes.apple.com/us/app/weatherfx/id539498084?mt=8
9. J. Nielsen, "Why You Only Need to Test with 5 Users," 2000. [Online]. Available: https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/

APPENDIX

APPENDIX A: CLIMAPP PROTOTYPE

Appendix A.1: Prototype (high fidelity)
Link:

Appendix A.2: Source code
Link: https://github.com/frksteenhoff/ClimApp

Appendix A.3: Prototype in InVision (low fidelity)
Link: https://invis.io/W3EQCCGSN

APPENDIX B: APP FLOW

APPENDIX C: INTERFACE ITERATIONS - MOCKUPS

Appendix C.1: Iteration 1

Appendix C.2:Iteration 2

APPENDIX D: TESTING

APPENDIX F: WHY YOU ONLY NEED TO TEST WITH 5 PEOPLE

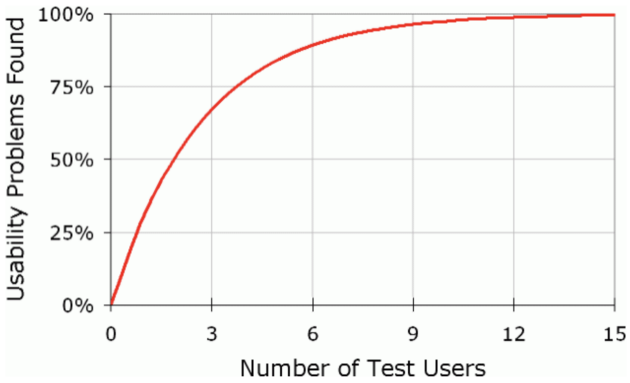

Figure 2. The correlation between number of test users and the usability problems found[9]