# Decision Support for Route Planning to Reduce Heat Stress Considering the Time of the Day

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Heat stress is a serious risk, in particular for certain groups like elderly or patients with multiple sclerosis or heart disease. Developments like the ageing of society, the increasing urbanisation (urban heat island effect) and the climate change are increasing the risk that people are affected by heat stress. One way to reduce those risks is to adapt the everyday behaviour, e.g. by performing purchases in the supermarket or pharmacy in the morning or evening when temperatures are lower.

Therefore we are presenting two different approaches for decision support tools that can help people to adapt their everyday behaviour. At first we're presenting a route planer for pedestrians that can find a route with minimal heat exposure. The second approach we're proposing is a tool that supports the user to select the point in time with a minimal risk of heat stress, considering e.g. the opening hours of a shop. In both cases we are utilizing, among other, remote sensing data of a thermal flight scanner.

Our results are showing that both approaches are able to reduce the heat exposure and therefore can help people to decrease the risk of heat stress in their everyday life.

## 1 Introduction

Heat is one of several natural hazards our society is faced with today. High temperatures cannot only lead to a discomfort, e.g. because of increased sweating, it can also have serious negative effects on the health.

In numerous studies an increase in both mortality and morbidity has been associated with a high ambient temperature (Zacharias, Koppe, and Mücke 2014; Basu 2009). For example an excess of mortality during the 2003 heat wave in Europe have been reported for several European countries (Johnson et al. 2005; Kovats, Wolf, and Menne 2004).

Certain groups are especially vulnerable to heat stress such as older people or people with health problems like high blood pressure, heart, kidney, liver or metabolic diseases (Ebi et al. 2004; Hübler, Klepper, and Peterson 2007). For patients with multiple sclerosis an increased body temperature can lead to a worsening of their symptoms (Guthrie and Nelson 1995; Davis et al. 2010).

In Addition to discomfort and health problems heat can have other negative impacts, e.g. on the task performance in office environments (Seppänen, Fisk, and Lei 2006).

Developments like the ageing of society, the increasing urbanisation and the climate change is making the adaptation to heat stress danger more and more important. For instance due to the tendency that a rising number of people is moving into the cities, the urban heat island effect (UHI) is gaining more importance in the future. Because of the UHI effect an urban area can be 8 °C to 12 °C warmer than the rural areas (Prashad 2014). This is caused by the fact, that urban materials such as asphalt, concrete, and bricks are storing the energy from the sun and releasing it later to their surrounding (Prashad 2014).

There are several steps that can been taken to reduce the risk of heat stress. For instance urban planning measures like more green areas or construction measures like air conditioning or building insulation. Another important step can be the implementation of a heat warning system that enables authorise, hospitals, or retirement homes to take the appropriate actions in time (Ebi et al. 2004).

Additionally, by adapting their everyday behaviour everybody can reduce their risk by themselves. For instance, activities should be performed in the morning or evening when the temperatures are lower.

## 1.1 Goals

The goal of our work is to help people adapting their everyday behaviour to reduce their heat stress risk. As a use case were looking at everyday actions like go shopping in a supermarket or pharmacy. Those actions usually cannot simply be omitted because there are necessary to challenge the everyday life. Since more and more people are living in cities and do not necessarily own a car, we are focusing on pedestrians.

One possibility to reduce the heat stress is to select the appropriate time to go shopping, because usually in the morning and evening the heat exposure is lower than middays. So, it can make sense to select a shop that is further from the starting point but has longer opening hours.

Another possibility to reduce the heat stress risk is the selection of an appropriate route between the start and the destination. For instance, a longer route with more shadows and green areas can have a lower heat exposure than a shorter route and so that selecting the longer route can reduce the heat stress risk.

## 1.2 Related Work

Several research projects have considered environmental factors for pedestrian routing in the paste. The AffectRoute routing algorithm proposed by Huang et al. (2014) for instance takes the affective responses to the environment into account, e.g. to find a route that a person considers safer. Sharker, Karimi, and Zgibor (2012) are proposing a method to find a health optimal route, considering several environmental factors like complexity of the walking trail (slope etc.) and weather (only "Good", "Fair" or "Bad"). A method to find a route with a minimal pollution exposure has been proposed by Hasenfratz (2015) in his PhD thesis.

The NaviComf framework for pedestrian routing proposed by Dang, Iwai, Umeda, et al. (2012, 2013), enables to improve the comfort considering environmental factors varying over time. The proposed framework uses a multi-factor cost model for the evaluation of the route and enables them to consider heterogeneous environmental information from multi-modal sensors like air temperature and humidity. To find a optimal route Dang, Iwai, Tobe, et al. (2013) are proposing three different algorithms, a bounded depth-first search algorithm, an adjustable dynamic planning algorithm and a heuristic particle planning algorithm. As a sample application, the authors implemented a routing app for thermal comfort navigation. The meteorological used for this sample application have been collected using a network of 40 micro-climate sensor nodes which detected air temperature and relative humidity.

### 1.3 Contribution

In this paper we are making contributions to finding a route with minimal heat stress as well as to find a point in time with a minimal heat exposure.

To find a route with minimal heat exposure we are using a different approach then Dang, Iwai, Umeda, et al. (2012, 2013). First of all we didn't have data of a mobile sensor network at hand, instead we're used the remote sensing data of thermal scanner flight as well as the data of weather station. Another contribution is the comparison of different thermal comfort measures like air temperature and heat index. A further difference is the application of static routing algorithm instead of dynamic one as used by Dang, Iwai, Umeda, et al.

Another impotent contribution of this paper is the finding of a point in time with a minimal heat exposure. The approach which we are proposing allows to find a place and a point in time within a given search radius with a minimal heat exposure, considering constrains like the opening hours of the feasible places. Thereby we're taking the heat exposure as well as the distance to the respective places in to account.

## 2 Story

- Motivation
  - heat is critical for humans
  - particular problems for risk groups (illness, old, etc)
  - walking to areas often done action in particular to typical locations (shopping, health care, etc)

    - those actions have to be done
- Problem definition
    - how to minimize the impact of heat stress on walking paths?
    - subdivided into:
        * for a given route?
        * When and how to walk typical routes, e.g. pharmacy, doctor
- method:
    - Goal of this paper: We want to provide a routing method to minimize the heat stress of typical walking actions
    - We do so by providing a value function for heat stress which can be used in route planning
- Evaluation:
    - Our data set
    - Evaluation 1 on routes given date in time. (pure routing approach) and its metrics
    - Evaluation 2: producing queries for typical walking tasks (our selection) and their evaluation
    - implementation as a demonstrator is produced and available at *homepage*
- Conclusion and contribution

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