Stage M2 Recherche / Master Internship / Master Thesis

Mesure de la Température Cutanée par Thermographie Infrarouge pour l'évaluation du Confort Thermique en Environnement Urbain / Skin Temperature Measurement by Infrared Thermography for the Assessment of Thermal Comfort in Urban Environments

Context:

In the face of climate change and accelerating urbanisation, cities are increasingly struggling with the critical challenge of overheating. Extreme events such as heatwaves and urban heat islands are becoming more frequent, intense, and prolonged during the summer months. As a result, urban residents are exposed to diverse warm microclimates in their daily lives when commuting between home, work, leisure, and commercial spaces, experiencing conditions that range from mild thermal discomfort to severe heat stress.

In this context, the ANR AAPG 2024 PRCE CoolPath project aims to enhance our understanding of how urban microclimates affect the thermal comfort of their inhabitants. The objective is to inform the development of sustainable urban planning strategies, in particular through the creation of cool pathways.

Residents' thermal comfort is affected by urban microclimates through two key mechanisms which alter their skin temperature: (1) passive processes, including heat and mass transfer within the body and at the skin surface with the outdoor environment; and (2) active processes, involving physiological thermoregulatory responses that regulate core body temperature around about 37°C.

Skin temperature is a critical parameter in defining thermal comfort. As humans, we do not perceive air temperature directly; rather, we sense changes in body temperature primarily through peripheral thermoreceptors located in the skin, the body's largest sensory organ. Infrared thermography has emerged as a promising, non-invasive tool for estimating skin temperature [1], which is essential for reliably predicting thermal comfort.

Objectives and methodology:

Non-invasive infrared thermography is a technique that uses emitted infrared radiation to measure the surface temperature of the skin. Human skin emissivity is similar to that of a black body with a value of 0.98 and is independent of wavelength. Within the context of the ANR AAPG 2024 PRCE CoolPath project, this master's internship aims to: (1) use infrared thermography to estimate cutaneous temperature distribution in an outdoor environment, (2) correct the temperature measurements using data from a wristband temperature sensor (Empatica EmbracePlus) that can be used as a reference, and (3) compare them with measures from finite contact (conductive) temperature sensors.

The methodology will consist of the following steps:

- Do a literature review of research on outdoor thermal comfort based on non-invasive infrared thermography technology.
- Perform a blackbody calibration test on the infrared camera.
- Conduct skin temperature measurements outdoors with the infrared camera, following the TISEM (Thermographic Imaging in Sports and Exercise Medicine) checklist [2], and compare them with contact (conductive) temperature measures [3].
- Correct the temperature measurements using a wristband temperature sensor (Empatica EmbracePlus) that can be used as a reference [4].
- Use image processing techniques to automatically detect the regions of interest (ROIs), such as the face, within the infrared thermal images and extract the skin parts of interest, considering that large individual differences in body shapes exist. Check also the Glamorgan Protocol for standardised ROIs.
- Test different methods to extract skin temperature (mean, median, maximum, and selected points) from various body segments, considering that large intraregional temperature variations exist [5].
- Identify technical and environmental factors that affect the accuracy of the infrared measurements outdoors [6], e.g. distance and view angle between the infrared camera and the participant [7], presence of sweat on the skin [8], and radiation background.

Candidate profile:

Student enrolled in a master's degree or equivalent with a focus on thermal/energy/mechanical/informatics engineering, or similar disciplines.

Additional appreciated skills and competences are:

- Experience in programming and image processing techniques.
- Knowledge of infrared thermography.
- Interest in interdisciplinary research.
- Independent and accurate work ethic, a strong sense of responsibility, and the ability to integrate into a team.

How to apply:

Please send your CV, transcript, and motivation letter to marika.vellei@u-bordeaux.fr and alain.sommier@u-bordeaux.fr.

Host laboratory:

Institute of Mechanics and Engineering (I2M), CNRS - University of Bordeaux, Bordeaux, France.

Duration:

6 months.

Remuneration:

Legal Minimum. About 600 euros per month net.

References:

[1] G. Tanda, Skin temperature measurements by infrared thermography during running exercise, Experimental Thermal and Fluid Science 71 (2016) 103–113. https://doi.org/10.1016/j.expthermflusci.2015.10.006.

[2] D.G. Moreira, J.T. Costello, C.J. Brito, J.G. Adamczyk, K. Ammer, A.J.E. Bach, C.M.A. Costa, C. Eglin, A.A. Fernandes, I. Fernández-Cuevas, J.J.A. Ferreira, D. Formenti, D. Fournet, G. Havenith, K. Howell, A. Jung, G.P. Kenny, E.S. Kolosovas-Machuca, M.J. Maley, A. Merla, D.D. Pascoe, J.I. Priego Quesada, R.G. Schwartz, A.R.D. Seixas, J. Selfe, B.G. Vainer, M. Sillero-Quintana, Thermographic imaging in sports and exercise medicine: A Delphi study and consensus statement on the measurement of human skin temperature, Journal of Thermal Biology 69 (2017) 155–162. https://doi.org/10.1016/j.jtherbio.2017.07.006.

[3] A.J.E. Bach, I.B. Stewart, A.E. Disher, J.T. Costello, A Comparison between Conductive and Infrared Devices for Measuring Mean Skin Temperature at Rest, during Exercise in the Heat, and Recovery, PLoS ONE 10 (2015) e0117907. https://doi.org/10.1371/journal.pone.0117907.

[4] H. Yoshikawa, A. Uchiyama, T. Higashino, ThermalWrist: Smartphone Thermal Camera Correction Using a Wristband Sensor †, Sensors 19 (2019) 3826. https://doi.org/10.3390/s19183826.

[5] D. Formenti, N. Ludwig, A. Rossi, A. Trecroci, G. Alberti, M. Gargano, A. Merla, K. Ammer, A. Caumo, Skin temperature evaluation by infrared thermography: Comparison of two image analysis methods during the nonsteady state induced by physical exercise, Infrared Physics & Technology 81 (2017) 32–40. https://doi.org/10.1016/j.infrared.2016.12.009.

[6] I. Fernández-Cuevas, J.C. Bouzas Marins, J. Arnáiz Lastras, P.M. Gómez Carmona, S. Piñonosa Cano, M.Á. García-Concepción, M. Sillero-Quintana, Classification of factors influencing the use of infrared thermography in humans: A review, Infrared Physics & Technology 71 (2015) 28–55. https://doi.org/10.1016/j.infrared.2015.02.007.

[7] X. Tian, L. Fang, W. Liu, The influencing factors and an error correction method of the use of infrared thermography in human facial skin temperature, Building and Environment 244 (2023) 110736. https://doi.org/10.1016/j.buildenv.2023.110736.

[8] V. Bernard, E. Staffa, V. Mornstein, A. Bourek, Infrared camera assessment of skin surface temperature – Effect of emissivity, Physica Medica 29 (2013) 583–591. https://doi.org/10.1016/j.ejmp.2012.09.003.