Assessment of indoor microclimate and thermal comfort in buildings: A thermographic approach

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Abstract

Assessing the indoor thermal parameters in buildings is a key priority in building management. Buildings should minimize their energy demand, but not at the expense of guaranteeing the adequate indoor microclimate and the thermal comfort to the users. Several tools and standard procedures are available to evaluate the indoor conditions of buildings. Infrared thermography could be used, in different configurations, both as a supporting or as an alternative tool to measure key indoor parameters such as wall temperature, air temperature, relative humidity, air speed. Experimental data show the feasibility of the thermographic method.

1. Introduction

Buildings account for a significant share of the global energy consumption. The different international policies aiming to reduce the impact of buildings, in terms of energy demand, should not come at expense of guaranteeing both the thermal comfort conditions for the inhabitants and the microclimate parameters for the maintenance of the building itself. Maintaining the correct hygrothermal conditions inside the building is beneficial not only to the building itself but also to the users. Several studies shows that the bad indoor conditions could have a detrimental effect to health, leading to the so-called Sick-Building Syndrome (SBS) [1]. The thermal comfort inside buildings is also related to the performance of building users. This is of peculiar interest in schools, where the research is focused on evaluating the connection between ambient conditions and learning [2].

To investigate and assess the environmental microclimatic conditions in buildings and the related thermal comfort parameters, several well established tools are available [3]. Infrared thermography (IRT) [4] could be used as a standalone tool or as a supporting method to survey buildings and evaluate the indoor conditions.

2. Materials and methods

The thermal comfort conditions could be evaluated by mean of parameters PMV (Predicted Mean Vote), which is an estimate of the expected average vote of a panel of evaluators for a given thermal environment and PPD (Predicted Percentage Dissatisfied), which is the percentage that quantifies the expected dissatisfied people in a given thermal environment [3]. Such parameters are numerical outputs of a method consisting of a model of correlation between the subjective human perception on a scale ranging from -3 (very cold) to +3 (very hot), and the ratio between the heat generated and released by the human body. Specifically, PMV and PPD have been both calculated by adapting the method developed by Fanger and included in standards [3].

An experimental campaign has been performed in different buildings located in Padova (Italy). The purpose of this evaluation is to understand the feasibility of surveys based on the infrared thermography technique.

Therefore, a standard instrument has been used to record microclimate parameters such as: air velocity (hot-wire anemometer), air temperature (dry-bulb temperature probe), mean radiant temperature (globe thermometer), relative humidity (capacitive humidity probe). Sensors have been placed at 1.1m height, i.e. at head height subject sitting, at abdomen height subject standing. Other physical quantities needed for the evaluation of thermal comfort have been derived from the previous ones.

Simultaneously, Infrared Thermography has been applied in the same location and the outputs of such experimental technique have been evaluated against the monitoring device described before. Quantitative infrared thermography is used to measure the humid air conditions in equilibrium in the indoor environment on thermodynamic basis. The use of thermal targets across room, chosen to fast reach thermal equilibrium within the environment, allows a distributed evaluation of air temperature. Finally, the use of a special ancillary device called IRpsicro [5] and a dedicated procedure allows the measurement of the air temperature, relative humidity and air speed using only IR thermography.

The results obtained with the different methods are compared and discussed, highlighting the possibilities and limitations of the infrared-based methods.

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