Modelling of IR images of sky and clouds

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Extended Abstract /Poster presentation/

Thermal radiation emitted by real objects is a phenomenon commonly used in Automatic Target Recognition (ATR) systems. In order to obtain effective detection algorithms, the radiative properties of both object and background should be known. So, the background modeling is an important research area in many laboratories working on efficient decision-making algorithms for target recognition.

In the presented work, the numerical method for the modeling of sky and cloud IR radiation is presented. Experimental data were collected by SWIR and LWIR cameras, in various environmental and weather conditions to provide extensive initial database of real sky and clouds IR images. Those images contained characteristic temperature profiles, recorded during all seasons, specific to the weather conditions of Poland [1].

Due to the complex nature of thermal effects in the atmosphere, it is virtually impossible to record all types of sky and clouds images that can be observed throughout a year. The actual thermal image of a sky depends on many factors like time of day, season, weather conditions and the geographical location as well as the parameters of a thermal camera itself. As a result, to create an effective detection algorithm, there is a massive amount of information to analyze. More input data taken into account means that the modeling could be more accurate and efficient.

Meteorological, specialized software for the dynamic atmosphere modeling use complex mathematical models based on differential equations. Their main purpose is to simulate physical characteristics of the atmosphere, including clouds development. Actual models have millions of degrees of freedom and it takes most powerful supercomputers to perform the calculations. Such models are far too complex for such narrow area of applications like the simulation of clouded sky background for the detection of aircrafts.

The analysis of the real, recorded thermal images of the sky revealed their random character, as both shape and location of the cloud can be treated as local event. This led to the conclusion, that for simulation purposes the image of a cloud could be described using appropriate probability function [2,3]. Furthermore, the cloud development process happens mainly in the vertical direction. This, in turn, resulted in simplified, two-dimensional approach to the choice of probability function instead of more complex three-dimensional solution.

As a result, the development of the method for the simulation of thermal images of the sky begun with the search for the most suitable noise generator. A pseudo-random function was used, but the typical functions available in programming languages didn't produce natural-like cloud images. In this case, the pseudo-random function should be "smooth", so the data between its discrete values could be interpolated. A well-known solution was developed by Ken Perlin [4] and Perlin noise is now commonly used to generate artificial, yet natural-like images. Perlin noise is created by summing up several harmonics of a base noise function. Finally, a Brownian fractal pattern is obtained.

Choice of independent variables determine the properties of the resulting cloud image. Two-dimensional noise is a best choice for simulated infrared images of the clouds. The next step was to convert noise patterns into virtual clouds. Exponential function was used to create "condensation level", above which the clouds are visible. A certain constant value was subtracted from noise distribution and all negative values were assumed zeroes in order to obtain single cloud on a clear sky.

IR Sky software was developed to simulate the thermal images of the sky, using aforementioned method. The resulting images are rendered according to the input parameters chosen by user. There are several advanced numerical procedures implemented

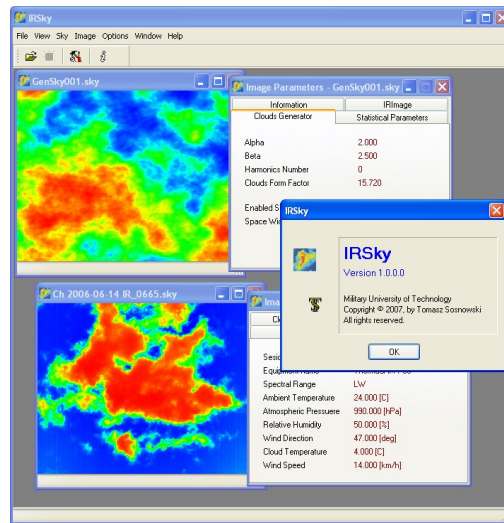in the IR Sky software to derive necessary parameters and characteristics needed in the sky modeling process.

Fig. 1. *Main windows of IR Sky software*

The images generated by IR Sky software were analyzed and the influence of radiative properties of sky and clouds background on the thermodetection process was investigated. The analysis were performed with Matlab-based software and procedures. Computer simulation of the process of thermodetection in three-dimensional space was performed using IR Analysis software, also developed at the Institute of Optoelectronics, MUT [5,6].

In this software, the 3D thermal model of a real object was placed against background image (thermal map of the sky) generated by IR Sky. There was satisfactory consistence achieved between real and simulated thermal images. The results obtained during the research can be utilized in the future works concentrated on decision-making algorithms implemented in various ATR systems.

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