Cloud Height Estimation with a Single Digital Camera and Artificial Neural Networks

Filipe Carretas [1] and Fernando Janeiro [2]

[1] Dept. of Physics, University of Évora, Portugal; Centro de Geofísica de Évora, Portugal (fcarretas@uevora.pt);
[2] Dept. of Physics, University of Évora, Portugal; Centro de Geofísica de Évora; Instituto de Telecomunicações, Lisboa, Portugal (fmtj@uevora.pt).

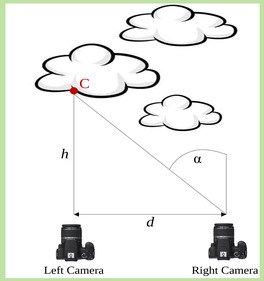
Objectives

- Develop a low-cost system, based on a single digital camera to measure cloud height;
- Present the working principle of a stereo vision system for measurement of cloud height;
- Present the working principle of a single camera system for estimation of the cloud height;
- Demonstrate the training procedure of the Artificial Neural Network;
- Compare the results from both systems.

Motivation

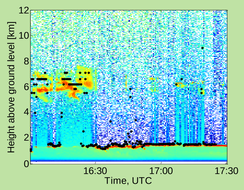
- Clouds influence the local weather, the global climate and are an important parameter in weather prediction models;
- Cloud height is an essential component in airplane safety when visual flight rules are enforced;
- It is important to develop a low cost system, that can be easily deployed in the field, enabling large scale acquisition of cloud parameters.

Stereo Vision System



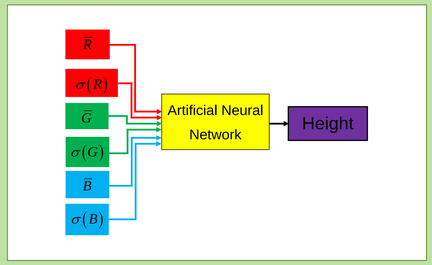
- Stereo vision (2 cameras + data network + 2 Raspberry Pi);
- Calibration required;
- Cloud height measured up to 10 km;
- Results in agreement with LIDAR measurements;
- Cross-correlation process used.

$$h = \frac{d}{\tan(\alpha)}$$



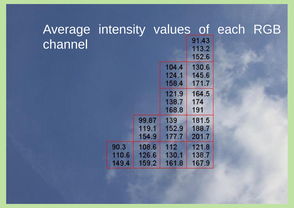
Single Camera System

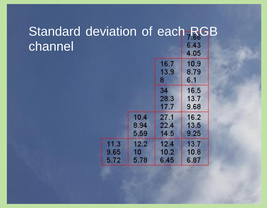
- Camera and Raspberry Pi;
- No calibration required;
- Cloud height estimated up to 4 km;
- Artificial Neural Network;
- No radial distortion influence.

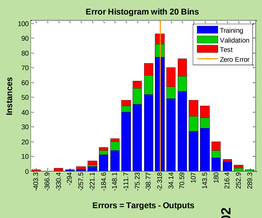


Artificial Neural Network Training

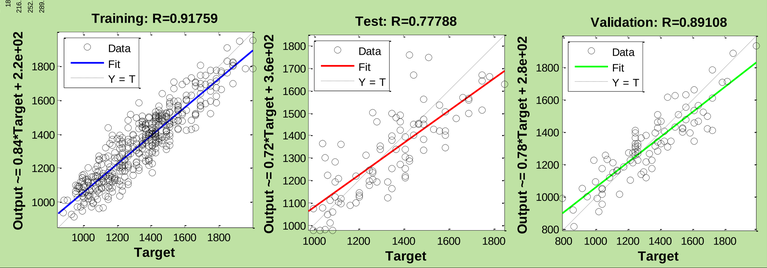
- Training in pattern recognition;
- Six inputs: average intensity values of each RGB channel and standard deviation of each RGB channel;
- One output: cloud height;
- One hidden layer with 12 Neurons.







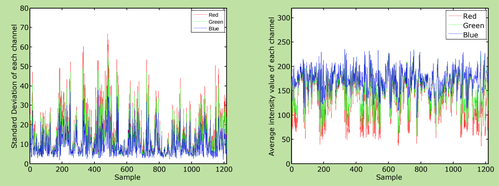
- Correlation ratio of 0.90;
- Most of the errors are within the interval [-200; 200] m
- This trained ANN can be used to estimate the cloud height.



Measurement Results

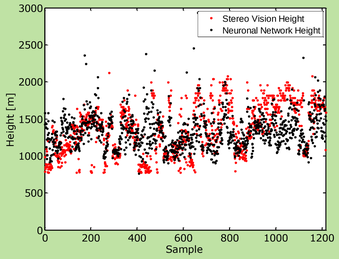
- Samples acquired during February of 2014;
- Data with cloud height below 4 km.

Artificial neural network inputs



ANN

Artificial neural network outputs



Conclusion

- Cloud height can be estimated using a single camera and an artificial neural network;
- Range of measurement needs to be improved;
- The accuracy of the system also needs to be improved;
- Larger sample of data needs to be acquired for a better training process;
- Larger data will provide a better comparison with the stereo vision system measurements.