Miniature Wind Sensing Module for Robotic Application: Design and Validation

Raphaël Dousson

Professor : Alcherio Martinoli
Assistant(s) : Wanting Jin

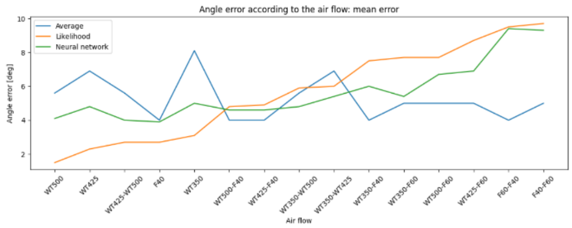
For detecting gas leaks in buildings, a wind sensor can detect the intensity and direction of the wind that could provide important information about the gas dispersion mode.

A large number of constraints need to be taken into account when embedding such a sensor on a wheeled mobile robot or micro aerial vehicle. The sensor must be light, compact, low-power, resistant to vibration, robot motion, dust, and gusts of wind. For this indoor application, the typical wind detection range should be between 0.5m/s and 2.0m/s.

A sensorboard prototype featuring thermo-based wind sensors mounted on a wheeled mobile robot is built using Sparkfun FS3000 1005 and 1015 sensors. The performances of these sensors are measured for different air flow conditions (speed (0.5m/s to 2.5m/s) and source Wind tunnel and fan)). The measured precision is high (~4%) while the accuracy is poor and inconsistent for different measurements. Three wind direction estimation methods are developed and tested as well. The effects of the number of sensors and the robot's motion are also measured.

The wind estimation methods are following. The likelihood-based method developed by T. Lochematter during his thesis is adapted to this new sensorboard. The new measurements are compared to a calibration set of measurements. An average based method takes the weighted average of the orientation of the sensors by their measurement. A neural network with one input per measurements, no hidden layer and two outputs (sine and cosine of the wind direction estimation) is also trained with a calibration dataset.

Following standard deviation are obtained for each air flow type for each wind estimation method:



The likelihood- and neural network-based methods are very sensitive to calibration. Their performances are therefore better for similar condition for calibration and testing. The error is also smaller for higher wind speeds. The average does not require any calibration. The likelihood-based method has a highly variable wind direction estimation error, while the neural network-based method has the most constant error

By virtually changing the number of sensors, we could observe that seven sensors gave significantly better wind direction estimation results with the likelihood- and neural network-based methods. The performances of the average-based method are similar for eight and seven sensors.

The wind speed is estimated by taking the maximum wind speed measured across all the sensors. The precision of the wind speed estimation could be increased by using only one sensor type on the sensorboard.

The likelihood-based method has the highest memory and computational costs and the average-based method the lowest. The neural network-based method has a high computational cost for training the model and a very low cost for testing.