windPRO

Technical Note

Validation of Photomontages from windPRO

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1 Introduction

This technical note gives an overview of the validation of the photomontage module in WindPRO and its associated models and databases. For an in-depth introduction to the module as well as further technical details, please consult the windPRO manual [1].

The three main issues in a visual simulation of wind turbines are:

1. The correctness of the position of the turbines
2. The proportion of the turbines in the view
3. How realistic the simulation looks like

The first and second points can be demonstrated be means of an example.

The third point is more subjective manner, as the visual appearance of wind turbines is changing continuously. As an example, then the shadow of a passing cloud will dramatically change the appearance of the wind turbines. The wind turbines will almost disappear while a second later when the cloud has passed over, they will stand out more brightly in the landscape. And the scenarios in between are numerous. In other words, it is only possible to illustrate a "one moment" situation, but off cause more weather-scenarios could be documented. windPRO offers a specific functionality to simulate different weather situations, please see the software manual.

2 Positions and Proportions

This first part – Figure 1 to Figure 9 - presents how the camera model is calibrated and how the position and proportion are calculated correctly.

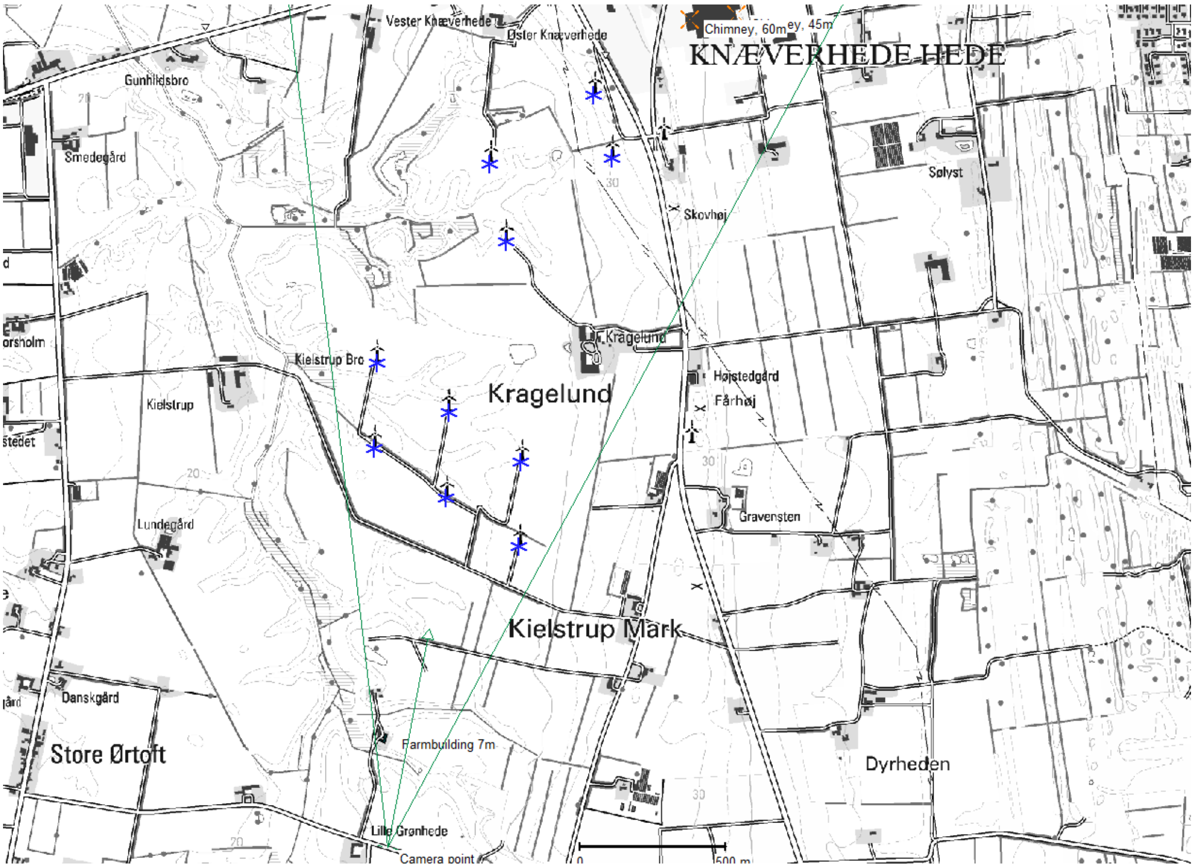

Figure 1: Overview of the different elements used in the demonstration: The wind turbines (blue symbols), the camera position (in green) and the control points (orange).

Figure 2: Picture without the wind turbines. The use of control points is essential in order to calibrate the model for direction and focal length. In this case the two chimneys on the right and the houses on the left are very suitable as they are located on each side on the picture and are far enough from the camera point.

2.1 Camera Model Calibration

Figure 3: A geo-referenced Google map image enables the user to identify the chimney very precisely. The height of the chimney is not fundamental but if available it can increase the accuracy.

Figure 4: The other control points (obstacle objects in blue) are used as a plain parallel figure for the nearby houses.

Figure 5: Picture with the symbols of the control point. The match for the chimneys and the houses with respectively the orange and blue symbols tells that the orientation and focal length of the camera are right (assuming that the position of the camera is exact).

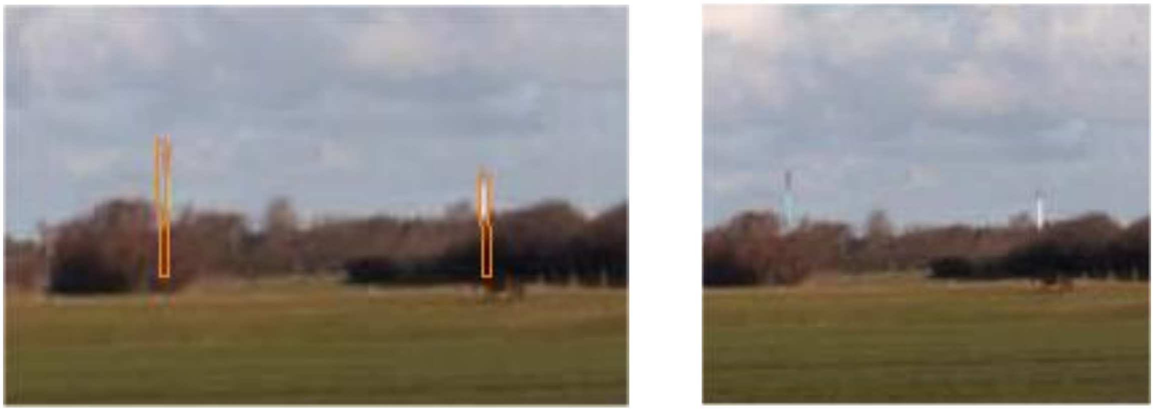

Figure 6: Zoom on the chimneys, with and without the symbol of the control points.

In addition to the right and left (Pan) calibration – Figure 6 - then it is also important to correct to the correct height by doing an up/down (tilt) calibration. The digital height model is very suitable for this purpose, see Figure 7. When the digital height contours are shown on the picture, then it is possible to correct for any tilt settings (up and down position). It is also possible to correct for any camera rotation if the camera was not precisely horizontal when the picture was taken.

Doing a tilt/rotation calibration is a very important step. As an example, see the Figure 7. If the turbines are to be rendered at the right behind the trees in the photo and only one good control mark for tilt calibration is available to the left (at the farm building), then the turbines are easily rendered so they look either too high or too low. In this example the rotation value has been adjusted to +1 degree.

In WindPRO two options are available for drawing the elevation contours:

- A yellow horizon line based on the entire elevation data file
- A wire grid rendering shown typically rendering the nearest 3 km elevation data.

Figure 7: Validating the model (tilt and rotation) using the digital height contours.

2.2 Rendering the Wind Turbines

Once the camera model is calibrated using both control points and height contours, and then WindPRO is able to deduce the right position and proportion of the wind turbines on the picture.

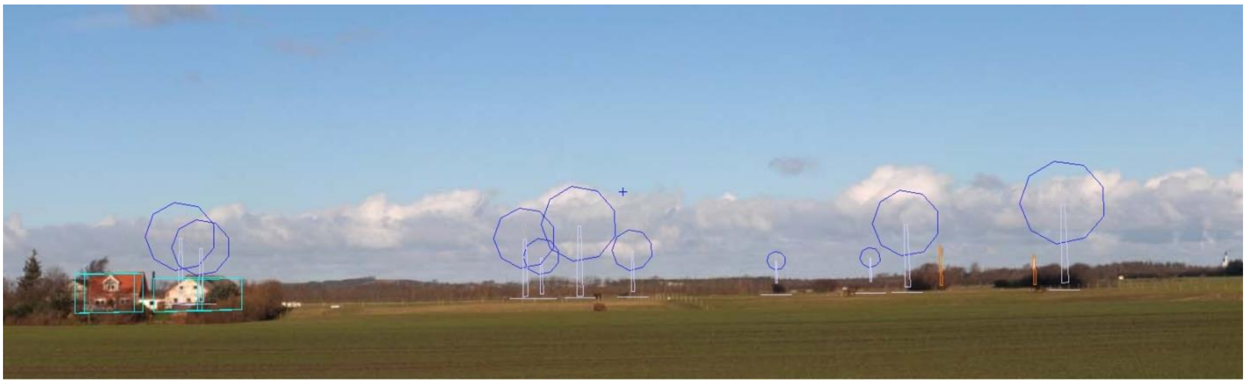

Figure 8: The position and dimension of the wind turbines are shown as blue symbols

The proportions of the wind turbines depend first of all of the distance between the camera point and the wind turbines. This distance is calculated from the coordinates of each object. The coordinates for any existing objects are typically imported from a GPS. We recommend validating the coordinates using a tool like Google Earth. In WindPRO, the export of coordinates to Google Earth has proven to be quite helpful and very reliable.

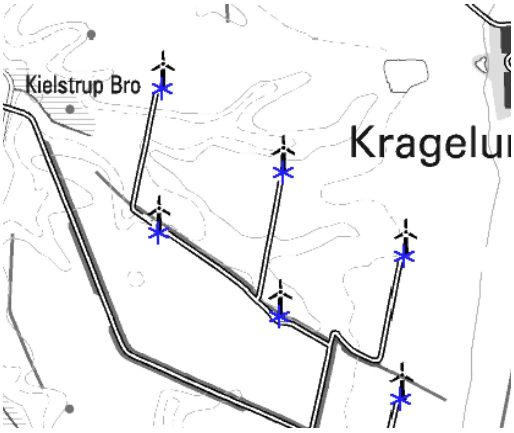

Figure 9: Same coordinates (of wind turbines, in blue) shown in WindPRO (left) and in Google Earth (right).

Secondly the dimensions of the different parts of the wind turbines (blades, tower and cabin) are based on the visual data input selected by the user. The characteristics of the wind turbines are typically found in the wind turbine catalogue of WindPRO. This database holds data for most of the new wind turbines models as well as for many of the older ones. EMD provides the dimensions of several turbine types in close collaboration with leading manufacturers. As an alternative, then the user is able to manually define the characteristics of the turbine. In the catalogue, more advanced visual aspects can be described like the dimensions of the tower (width at bottom and top) and the shape of the nacelle. If no specific data are available, the program will use a standard shape, scaling to the right dimensions as defined by the user. The generic standard shape is rougher and tends to overestimate the size of the nacelle (cabin) and width of the tower (as a conservative assumption).

It is also possible to define the color of the wind turbines and add a logo on the nacelle.

Finally, an eraser tool is used to delete the parts of the visualized wind turbines which are hidden by the landscape or any terrain features such as trees or buildings. Typically, this will be the lower part of the tower). This task is based on the users' ability to estimate the hidden parts.

3 Realistic Simulation

A realistic photomontage relies not only on the right position and dimensions but also on the light effects. As mentioned previously, the light conditions may vary a lot within a short period of time so that it seems impossible to obtain a result for all the different situations.

WindPRO assumes that the distribution of the sun-light is uniform (all the wind turbines receive the same amount). Still, the lighting and the resulting exposure to the sun is precisely calculated by the software. WindPRO combines the date and the time of the day the picture was taken with the latitude of the site to simulate how the sun rays fall on the turbines and thus how bright or shadowed turbines should appear. Moreover, the intensity of the light can be decided through various sky coverage options (such as clear sky, overcast and, fog).

Another setting enables the user to define the main wind direction so that the rotor is simulated perpendicular to this direction. In that way the photomontage is configured to represent the most common configurations of wind farms in normal operations.

Finally, this sample visualization is compared to the real case on the next page – Figure 10 – Figure 14. The setup proves that, provided a good desk study has been performed and care has been taken with all elements of the process, then the photomontage is so realistic that it is very difficult to see the difference with the real wind farm.

Figure 10: Picture without the wind turbines

Figure 11: Wire frame landscape with rendered turbines

Figure 12: Photomontage with rendered turbines.

Figure 13: Photo with real turbines

4 Acknowledgement

Lars Enevoldsen of the Municipality of Frederikshavn, Denmark is acknowledged for providing the photos for this case study.

5 References

[1] Per Nielsen et al: *WindPRO 2.7 Manual: Chapter 5 – Visualizations*, October 2011, EMD International A/S, Available from http://help.emd.dk