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Vision-based Visibility Estimation: From Fog Detection to Complete Visual Range

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In air traffic management (ATM) and monitoring of critical infrastructure, the exact description of the near surface atmospheric state - and thus the visibility - is an indispensable basis for situation awareness and any further weather forecast.

In order to overcome the drawbacks of the currently subjective reports from human observers, we present an innovative solution to automatically derive visibility measures from standard cameras by a vision based approach.

The certified state of the art for automated visibility measurement is represented by visibility sensors, such as those e.g. used for RVR (Runway Visual Range) measurements. These sensors only allow a very local measurement, whereas camera-based methods enable a representative measurement of the visibility in the entire environment of the camera location. A variety of camera-based approaches use physically based models to derive a measure of visibility (e.g. the Koschmieder model or contrast measurements, as well as models for measuring light reduction). The Dutch weather service (KNMI) uses similar visibility detectors and methods as are used for our system called "visIvis®" (e.g. feature-based methods or de-hazing methods). In addition to the restriction to a single specific method, often additional special requirements (e.g. the measurement object or the land mark must lie on a straight line with two cameras) complicate the use of these methods for a representative measurement of the entire scene.

It will be shown how the visIvis® system can detect automatically most suitable areas for visibility estimation within the camera-covered range based on a variety of detection algorithms, automatically tunes its detection parameters, and automatically derives fog covered areas. Furthermore, by coupling visIvis® with georeferenced data, a pixel-precise depth map is deduced from digital surface and terrain models and user orientated visibility classes can be defined (customized or according to meteorological relevant thresholds). Based on this mapping, visIvis® is able to derive representative visibility measures for complete visual range, that can be reported in customized or standard formats (e.g. METAR).

The presentation will give insight on a recent visibility measurement study for synoptic meteorological applications in cooperation with Deutscher Wetterdienst (DWD), the German National Meteorological Service. Special focus was laid on night scenarios, which pose challenges on a camera based measurement system, e.g. light sensitivity of the sensor or availability of representative landmarks. In addition, we will show how to generate added value by extending the concept of vision-based visibility measurement to other weather-related parameters. In the present study it was investigated, which steps are required by transfer learning principles to adapt the

system towards other camera-based observations. Results will be presented from evaluations in different challenging application scenarios.