Identifying forest insect damages from hyperspectral airborne images

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Low-cost, miniaturised hyperspectral imaging technology is becoming available for environmental monitoring. When operated using small unmanned aerial vehicle (UAV) platforms, this technology can be efficient in carrying out small-area inspections of anomalous reflectance characteristics of objects at a very high level of detail. For larger areas, small manned aerial vehicles (MAV) are more efficient but in this case level of details is not high.

Increased frequency and intensity of insect induced forest disturbance has established a new demand for effective methods suitable for mapping and monitoring tasks. The objective of this investigation was to study the feasibility of a novel miniaturised hyperspectral frame imaging sensor in identifying forest insect damages. The sensor, developed by VTT, operating in the wavelength range of 500-900 nm was used to identify mature Norway spruce (*Picea abie*s L. Karst.) trees suffering from infestation, representing a different outbreak phase by the European spruce bark beetle (*Ips typographus* L.). The sensor was operated using both UAV and MAV platforms. We developed a new processing method for analysing spectral characteristic for high spatial resolution photogrammetric and hyperspectral images in forested environments, as well as for identifying individual anomalous trees.

For the UAV data the dense point clouds, measured using image matching, enabled detection of single trees with an accuracy of 74.7%. We classified the trees into classes of healthy, infested and dead, and the results were promising. The best results for the overall accuracy were 76% (Cohen's kappa 0.60), when using three colour classes (healthy, infested, dead). For two colour classes (healthy, dead), the best overall accuracy was 90% (kappa 0.80). For the MAV data the best results for the classification accuracy of broadleaf trees was 96%, healthy spruces 55%, infected spruces 64% and dead spruces 81%. The overall accuracy was 64.3% (Cohen's kappa 0.47). It was challenging to classify healthy and infected spruces because their spectral features differed only slightly from each other.

We expect that the survey methodology based on high resolution hyperspectral imaging will be of a high practical value for forest health management, indicating a status of bark beetle outbreak in time. Both platforms were practical for health management but there were some differences in the flexibility and the areal coverage of the monitoring. It was concluded that the novel light-weight, low-cost remote sensing technology enabled new possibilities for the early identification of insect damages.

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