Development of a minimalistic low-cost UAV platform for simple airborne measurements

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Abstract: For specific tasks in field phenotyping, e.g., georeferencing of new experimental plots for upcoming observations, there is the need of simple, often short-termed airborne measurements. For this scenario we developed a minimalistic low-cost UAV platform. This platform can be easily adapted to different sensor setups. Due to its price and simplicity it can be constructed multiple times and so be used simultaneously. A first version of our flexible UAV software framework ("SimpleUavAdapter") is available and first test flights with simple measurements have been completed successfully. To further simplify the execution of GPS-triggered measurement tasks the development of a lightweight scheduling component ("FuRIOS client agent") is planned.

Keywords: Unmanned Aerial Vehicle (UAV), Remote Sensing, Phenotyping, Precision Agriculture

1 Motivation

In the area of field-phenotyping complex, time-consuming and often multi-sensor based screening methods are frequently needed. An example is here the classification of plant performance or energy absorption based on multispectral data (compare [B+15]). Besides these complex tasks there is also the need of simple, often short-termed measurements like a quick inspection of a specific area (plot) or environmental monitoring on given positions. To later systematically conduct such (simple and complex) screening tasks a specialised information system called "FuRIOS" ([BB16]) has been developed at the Jülich Plant Phenotyping Center (JPPC). This also includes the access to a comprehensive database backend through the integration of "PheOMIS" ([Sc13]) for managing experimental results.

Concerning phenotyping activities at JPPC there is a demand for both approaches. For the first class of so-called "deep phenotyping" related measurements existing platforms like the "IBG-2 Copter" (UAV) or the "FieldCOP" (UGV) can be utilized. Although these systems are also suited for the second class of simple measurements they are completely oversized for these tasks, especially concerning operating costs, logistic efforts and the complexity of configuration as well as sensor adaptions. Also availability is limited. Currently at JPPC only one of each UGV and UAV system exists.

To overcome this limitation a prototype of a simple low-cost UAV sensor platform has been developed. With hardware costs around 60€ for the basic UAV components and

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easy-to-follow assembly instructions it can be easily manufactured, customized and deployed on multiple locations. Essential is here the simple integration of new sensors due to the simplicity of the software framework and our UAV.

2 Construction and customization

Most UAV systems rely on multicopter based approaches. This can result in proper and flexible solutions. Disadvantage here is that for the establishment of a robust (crash tolerant) aircraft quite expensive components and spare parts are needed. The so-called “ArduSmartPilot” project (http://www.ardusmartpilot.de) from Reutlingen University published in 2014 offers a different solution and is freely licensed (CC-BY-NC-SA). This UAV is based on an extremely durable throw glider (Miniprob Felix 80) and around 13 low-cost model making components. Basically a “toy” plane is converted to a motorized aerial vehicle with an elevator, rudder, and propeller (see Fig. 1). This setup provides limited payload (around 120 gram), but enough for a lightweight RGB or even a multispectral camera (example: Parrot Sequoia).

Essentially the component list and assembly instructions have been directly adopted from the original “ArduSmartPilot” guide. The only major change was to replace the “Arduino Pro Mini” and “BTM-222” Bluetooth module with a “Genuino MKR1000 Wi-Fi” SoC-module to enable remote controlling with distances significantly above 100 meters, save payload and to increase the maximum possible Arduino program size.

The sample application of the “ArduSmartPilot” project provides two separate programs: the Android remote controlling APP and the Arduino UAV control agent. That was a good starting point for our platform, especially for GUI design. But the source code turned out to be hard to adapt due to the limitations of the underlying development platform (Processing) and the not existing abstraction layer for the flying and sensor hardware. Since good adaptability to different sensor setups was a major requirement these two programs have been completely (re-)developed by directly using the standard Android SDK and distinct C-libraries. This encapsulates (“wraps”) access to the various sensors and flying control components. Our UAV framework is currently named “SimpleUavAdapter”.

In our framework the measurement of (sensor) data is initiated and dispatched by our rewritten Android APP using MQTT messaging. Subsequently, data is plotted and presented to the user based on the open-source (Apache 2.0 license) library “Androidplot” (http://www.androidplot.de).

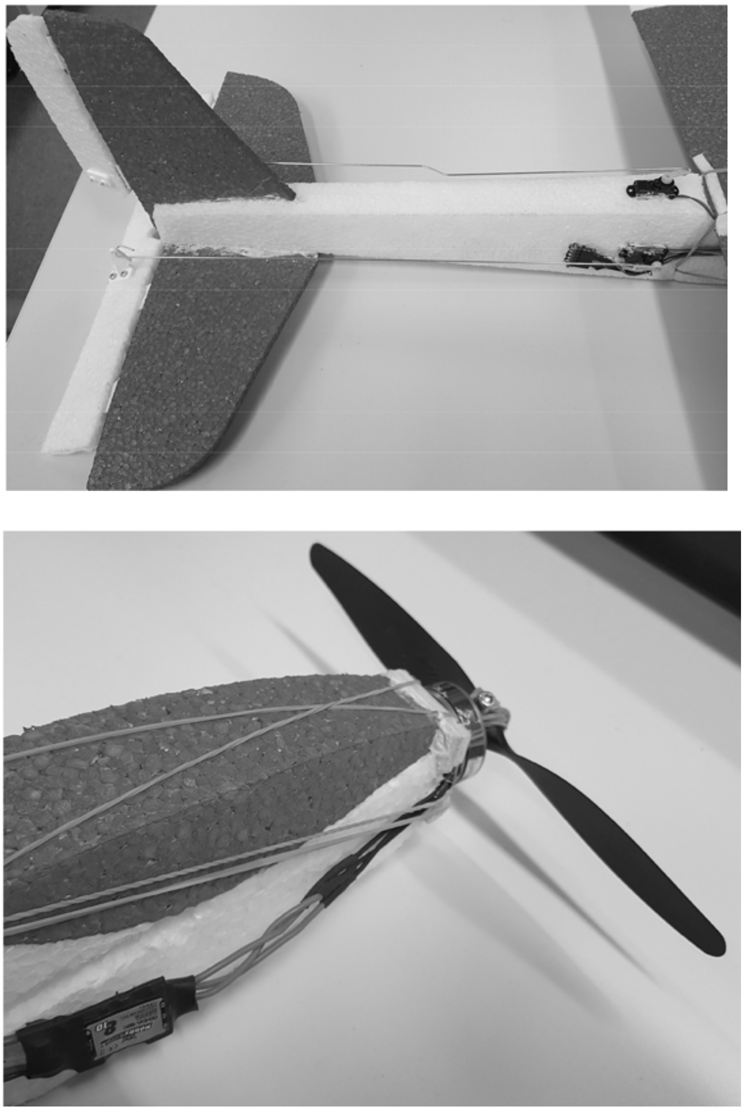

Fig. 1: Setting up a controllable rudder (a) and propeller (b) according to the "ArduSmartPilot" instructions

3 First tests and results

For our first test scenario we used a setup of a temperature sensor (DS1820), an accelerometer (MPU6050), and a low-cost GPS-logger (U-Blox Neo-6M). Besides some problems concerning flight stability the GPS-aware temperature measurements have been carried out successfully. Also the "temperature hotspot" (fire place in the field) could be localized in the measurement data.

After improving the flight characteristics our UAV the temperature sensor and accelerometer have been replaced by a lightweight multispectral camera (Parrot Sequoia). Due to the flexible software architecture of our "SimpleUavAdapter" the necessary changes (hardware layer) were easy to implement. Now in a larger and more realistic test scenario (see Fig. 2) parts of a wheat field could be successfully approached and monitored. A first evaluation of the multispectral data (see Fig. 2) showed reasonable results (same spots of stripe rust), comparable to the measurement results of the far more expensive UAV "IBG-2 Copter" (based on an AscTec Falcon-8).

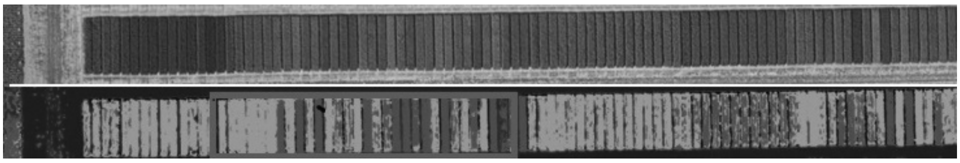

Fig. 2: Overflight image of wheat stocks (upper part) and mapped results of the multispectral images (lower part) acquired by our low-cost UAV platform.

4 Conclusion and outlook

The development of our low-cost UAV sensor platform is still in an early stage but first test flights and measurements have been carried out successfully. A first version of our framework "SimpleUavAdapter" (Android APP + Arduino UAV control agent) has been produced. The UAV can be controlled via our Android APP and data from all configured sensors is accessible and persisted. Still the remote control has to be fine-tuned and georeferenced sensor data has to be checked in more detail. Still the first results are promising and the flying / control range is sufficient for our experimental needs. An important next step is the development of a "FuRIOS client agent" for our UAV to simplify the execution of GPS-triggered measurement tasks like capturing RGB images.

References

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