Open Source and Archaeology:

The next level. Building and developing hardware projects.

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Abstract: after many years spent in software testing and developing (OpArch project and ArcheOS) we reach an high quality level in data elaboration, management and spreading. For this reason in 2008 Arc-Team's research was focused on some Open Source hardware projects to increase the quality level in data acquisition and to bypass some of the most common problems in archaeological excavations.

With this contribute we would like to present some of these projects; in particular we would like to explain our experience in building an Open Source UAVP (Universal Aerial Video Platform) at a reasonable price. The UAVP is a flying object (quadrotor), ideally suited for making aerial videos and photos. The great stability of UAVP's flight and the simple and intuitive commands allow archaeologist to take aerial pictures of layers and sites.

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Preamble

In the last years, our society (Arc-Team s.n.c.) was dedicated to the research into the application of Free and Open Source Software in archaeology.

The good results we achieved, thanks to the high performance of this kind of software, allowed us to satisfy most of our professional requirements. Besides we have to take into account the encouraging perspectives connected with the fast and exponential development of FLOSS (Free/Libre and Open Source Software).

Actually we are able to fulfil most of the needs that a modern archaeological excavation requires, maintaining at the same time a competitive level with closed source software. For example, using ArcheOS we are able to handle data elaboration, management and spreading.

Despite these favourable conditions, there are still problems in our methodology, directly connected with data acquisition. In fact in our opinion, considering the modern technologies, this sector has wide margins of improvement.

During 2008, this situation drove us, on one hand to go on in our research direction testing Open Source projects, on the other to consider the option to solve some of these problems not with software, but experimenting hardware solutions.

As a consequence we decided to make a further step in the Open Source world, and to experience “Open Hardware” projects.

In the next chapters we will describe our attempt to solve one of these problems in data acquisition (aerial photography) building an UAVP (a flying Open Source drone).

Aerial archaeology

As we wrote, one of the principal problems we found in data acquisition is connected with aerial archaeology, and in particular concerns the possibility to obtain good aerial pictures, both in intra-site projects (like archaeological documentation) and in extra-site projects (like survey or photointerpretation), where is important to analyse broad portion of territory.

Obviously this second requirement excludes solutions like mechanical arms, scaffoldings or telescopic ladders, cause of their limited height and mobility.

For this reason, since the beginning we focused our research on the construction of a flying device, able to take pictures and to reach elevated heights. At the same time was important to preserve a sufficient maximum range and a good manoeuvrability.

Under these conditions, the possible solutions are three:

1. a kite (that flies thanks to the wind)
2. an aerostat (like an aerostatic balloon or dirigible, that flies for buoyancy)
3. a flying drone like a UAV (Unmanned Aerial Vehicle)

After a fast analysis of these three choices, we decided to reject the first two options.

In fact a kite, though it allows a good positioning on the target (especially using a static kite), it does not suite to different situations of archaeological excavations. Particularly difficult (if not impossible) would be, for example, an indoor flight (like could require an intra-site documentation in a church or in a palace).

In the same way both an aerostatic balloon and a dirigible would be too influenced from atmospheric conditions, especially in outdoor flights.

To come to the point, the first two solutions are too connected to the presence/absence of wind to be used continuously during an excavation and they can not guarantee the manoeuvrability and versatility required in different situations.

Considering our needs, the option to build a flying drone, like an UAV (Unmanned aerial vehicle), seems to be the best choice. The main problem was to find a good Open Source project regarding the construction of such a complicate device.

The Open Source drones

After an accurate internet research, looking for Open Source UAV projects, we decided to reduce our options to two principal prototypes: the Paparazzi project and the UAVP.

The first project's aim is to develop hardware and software to build different kind of UAV drones, while the second is more specifically oriented to the construction of a quadrotor. In both cases the software and the hardware is released under Open Source license.

For this reason both the Paparazzi Project and the UAVP have the requirements we need: they concern the construction of an UAV and they are Open Source.

From a certain point of view there are no particular reasons to choose one project in comparison to the other, even if the Paparazzi Project would let more freedom regarding the typology of the drone. Anyway, considering the practical side, the experimentation on a UAVP gives the advantage to concentrate since the beginning on the construction of a quadrotor (the flying drone that, according to our perspectives, has the best chance to adapt itself to the wide range of archaeological applications). In fact the Paparazzi Project, which is not oriented on a particular kind of UAV, does not release specifications about the mechanical components and, until now, is used in most cases on models of aircraft (better in survey or photointerpretation than in intra-site archaeological documentation). On the contrary the UAVP is strictly connected to the quadrotor typology. This drone is very stable and it can maintain a stationary flight on a point, a very important ability for the documentation of small areas.

Fig. 1 - the UAVP.

These considerations finally drove us to choose to test the UAVP instead of the Paparazzi Project.

The construction of the UAVP

Analysing the complexity of this kind of projects (the construction of an Open Source hardware), we have to say that specific knowledges are necessary (not included in a normal archaeological vocational training).

For example, in building our UAVP, we collaborated with Sergio Tondini (expert in modelling) and with Mauro Martinelli (electronic engineer). Moreover we needed the precious help of Wolfgang Mahringer,

one of the main developer of the project.
In particular, we did not find many difficulties assembling the mechanical part (“frame”), while the electronic components were effectively more complex (at this stage would be necessary to have a minimum competence in soldering circuits and a basic knowledge about concept like motherboard, processor, etc...). However the basic elements are few (many are optional) and it is possible to buy some preassembled SMD (Surface Mounting Devices), like the motherboard (available already populated).

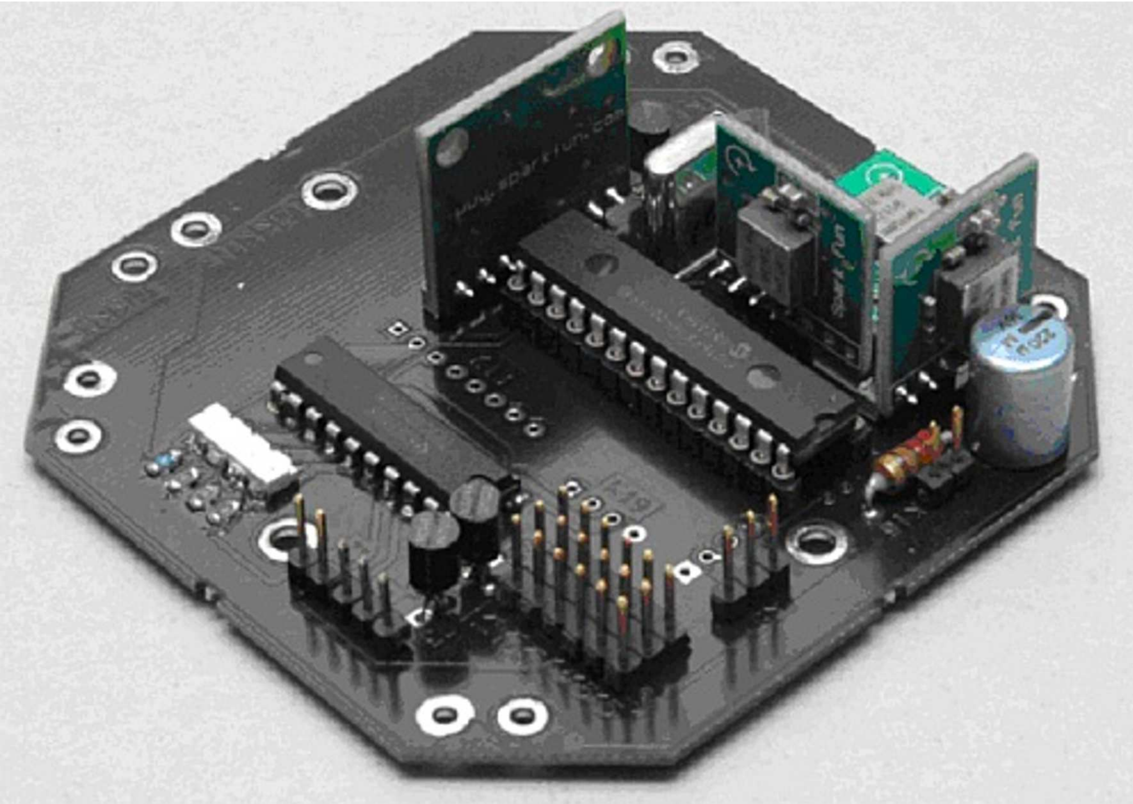

Fig. 2 – the populated motherboard.

Another difficult step can be the UAVP's programming and the help of an expert can speed up this process. In the same way it is important not to underestimate the necessary time to learn how to drive a quadrotor. In fact this drone is different in many aspects from other flying models.
Our final prototype is composed of a mechanical part with a carbon fiber frame and a support for a digital camera, equipped with an additional servomotor for its orientation. The electronic component is restricted to the essential elements (motherboard, gyroscopes, processor), to a linear acceleration sensor and to an electronic compass. Currently we did not integrate the UAVP with a GPS receiver, though this is one of the most probable future development.

The remote sensing device

One of the main component of our system (projected for an archaeological use) is the remote sensing device. As we wrote, the solution we adopted is composed of a support for a digital camera with an

additional servomotor that allow to orient the camera on the "z" axis (while for the "x" and "y" axis is possible to use the rotation of the drone).
Such a system can be operated from the ground through a radio control (RC) with eight channels: six channels are used to drive the drone (up, down, right, left, forward, backward), the seventh to orient the camera (on the "z" axis) and the eighth to take a picture. This option is possible thanks to a chip (PRISM) directly connected to the photocamera, which receives the radio signal (from the RC) and convert it into a infra-red (IR) signal. In this way it is possible to cover long distances thanks to the radio waves (while the IR signal can reach a maximum range of four meters). Obviously, this procedure works correctly only if the photocamera is equipped with an infra-red remote control.
Another very important component in our UAVP is a system to control the shot of the camera from the ground. We overcame the problem using a wireless videocamera combined with a portable monitor. This solution allows us to visualize in real time the photocamera's field of vision.

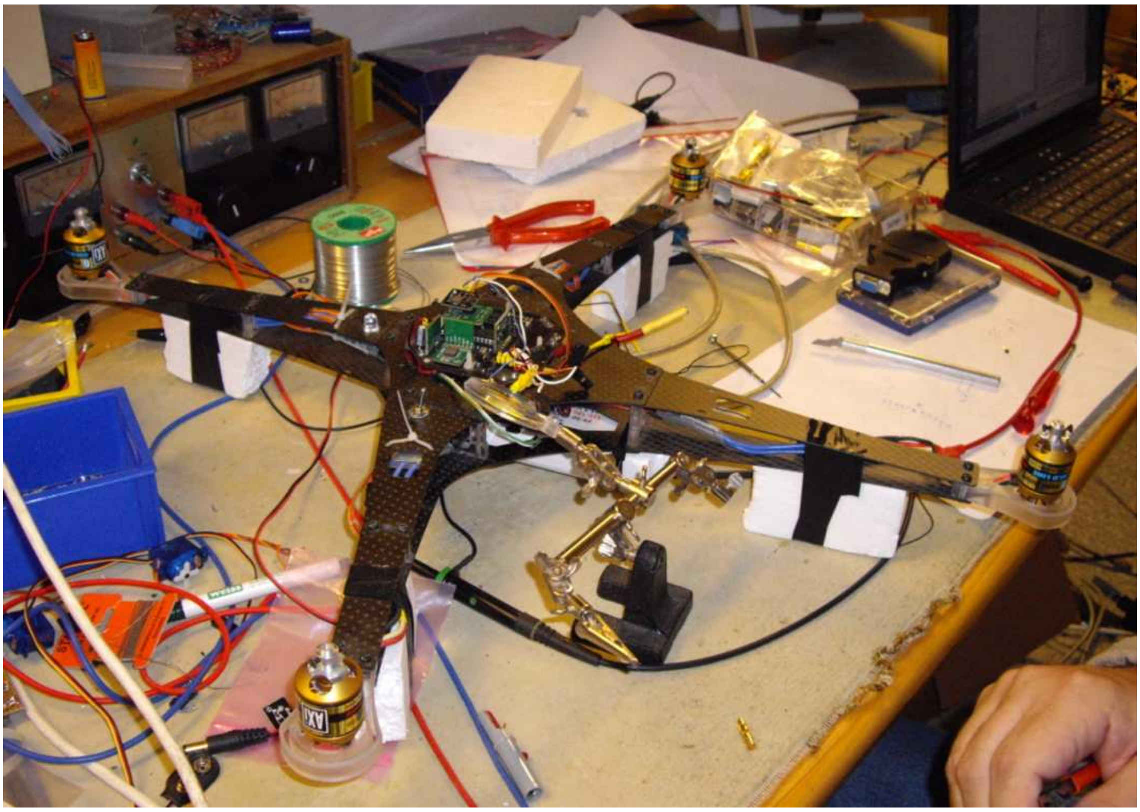

Fig. 3 – the construction of our prototype.

The first flying tests

When we finish the construction of the UAVP, we started the testing phase. Thanks to the help of Wolfgang Mahringer we could experience the stability of flight and the manoeuvrability of our prototype. The results of this first flying test were absolutely positive.
The stability in particular was undoubtedly satisfactory. The model is perfectly able to maintain a stationary flight on a target (a very promising feature for an intra-site archaeological documentation).
The manoeuvrability is also very good and certainly sufficient for a indoor use.

It has to be said that both of these aspects are directly connected with the pilot's skill. For this reason it is highly recommended to spend some time in training, starting with a computer simulator.

Possible applications

The main aim of our project is to test the possible application of a flying drone in archaeology, especially to optimized our methodology in data acquisition.
Until now we were able to build a working prototype of UAVP, equipped with a remote sensing photographic device and a real time ground control system.
On the bases of the first tests, the drone demonstrated high potentiality, thanks to its stability and manoeuvrability.
From this point on our experimentation provides a test phase directly on the field, to verify if these potentialities can develop in a real use of the UAVP in archaeology.
These checks will try to cover the most number of possible archaeological applications to verify the versatility of the model.
To achieve this result we will consider projects that provide the analysis of broad part of territory, like survey, photointerpretation and extra-site documentation. In this way we will hardly test the battery endurance (which is connected to the drone's maximum range) and the mobility on the “z” axis of the remote sensing device (especially for the photointerpretation). Moreover we will consider the possibility to implement the UAVP with an automatic guidance system using a GPS receiver.
At the same time we will evaluate the capacity of the model to fly in small ambient, working on intra-site archaeological and architectonic documentation, as well as its manoeuvrability in indoor situations (churches, palaces, monuments, ...). The remote sensing device will be also tested to verify the camera support movement in horizontal direction (to map archaeological layers) and in vertical direction (to document architectonic walls).
Finally we will experiment the use of the UAVP in difficult access areas, like First World War's sites placed in high mountain landscape and medieval castles build directly on gorges, ravines or caves (a typology that in Italy is known under the name of “covolo” or “castello in corona”).
In case of positive response in all of these experiments, the UAVP would be able to overcome most of the common problems we found in aerial archaeology. For example this prototype does not imply logistic difficulties (the model is small, simple to transport and does not require a complex ground support). Moreover it can solve some safety problems, especially in those situations where operators have to work in precarious conditions, like in many architectonic documentation. In this field the UAVP allows to take picture without excessive distortions, thanks to its ability to fly directly on the target.
This capacity would be also important in the difficult access areas, to document structures that normally are not possible to reach.
At the moment we are testing the UAVP in our archaeological fieldwork, obtaining promising results.

Future development

The benefits of an Open Source hardware project can be considered the same of FLOSS. One of the most important is the freedom to modify and further develop the project, also thank to the collaboration with the users/developers community.

This characteristics is an added value for the UAVP. In fact, though currently this prototype represent the best answer to our professional needs, it is already possible to consider some further development, partially provided bye the project's developers (like the improvement of the electronic components with a GPS receiver). Moreover the fast diffusion of Open Source flying drones allows a continuous comparison with parallel projects, like the Paparazzi project and the new NG-UAVP (without excluding the possibility of a partial integration between different models).

From our point of view, the UAVP gave us the chance to build a good flying platform for remote sensing, allowing our team to deal with some “frozen” research sectors. For example we can reactivate our experimentations on photogrammetric stereo-reconstruction with Open Source software. In fact, with a tested and reliable remote sensing system, the 3D documentation with photogrammetry becomes an option also for emergency excavations (normally characterized by a chronic lack of time). In parallel we are currently verify the practicability of an implementation of the UAVP with an hardware device for a 3D laser documentation. This research is actually in a very basic stage.

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