The terrestrial and aerial components of a European spatial and urban mapping project

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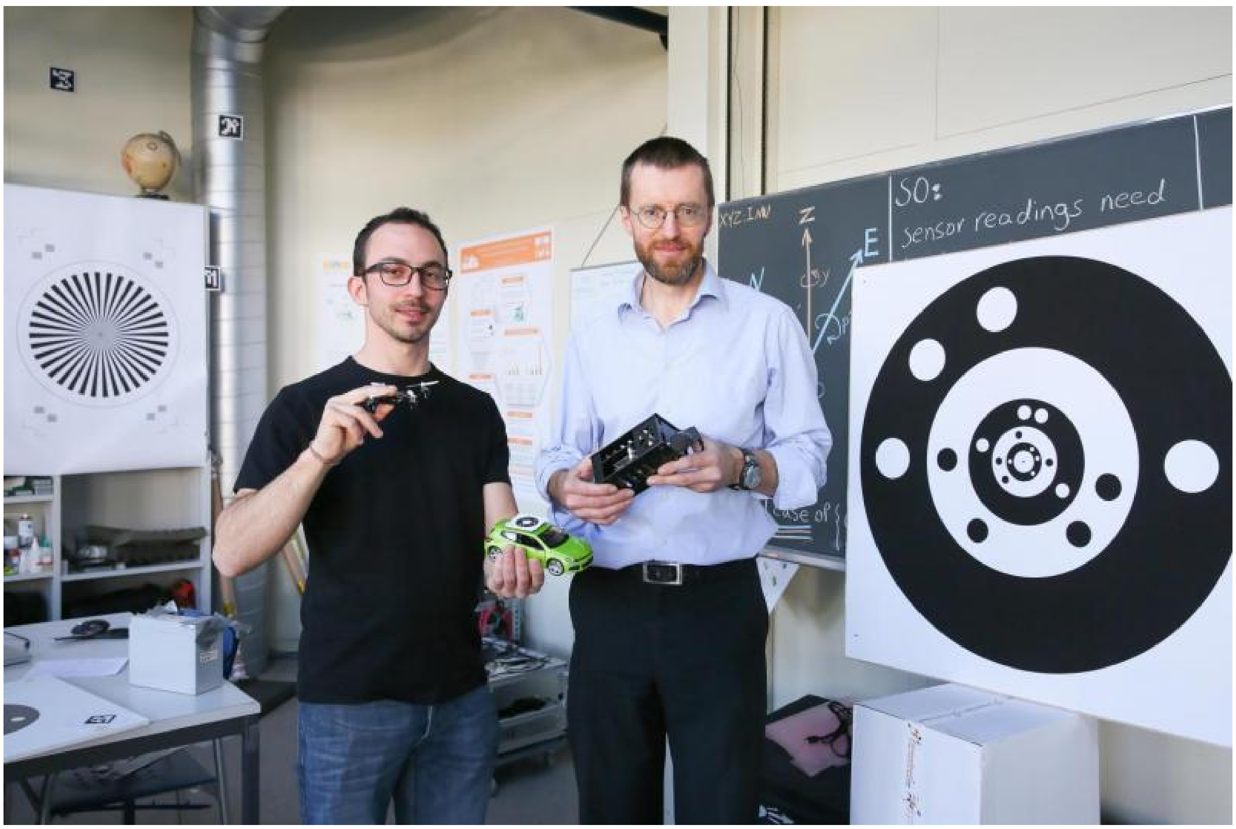


Davide Cucci and Jan Skaloud, from Geodetic Engineering Laboratory. Credit: Alain Herzog/EPFL

Developing a good, high-resolution 3-D map is a long, tedious and expensive process: a vehicle scans the surrounding environment from ground level up to the top of roofs or trees, while an aerial perspective is added using a drone. But a new approach, in which the terrestrial vehicle and drone are operated in tandem, has now been developed as part of a European project called mapKITE. EPFL researchers are involved in the consortium, which is funded by the H2020 program, and have designed some of the key components of this breakthrough technology. These include technical features – such as the target – that allow the drone to 'latch' virtually onto the vehicle.

One look at the current approach to 3-D mapping shows why combining terrestrial and aerial techniques makes sense. For example, to map out a long corridor like a road, river or railway, the drone has to work segment by segment, following markers on the ground. For control reasons, it has to remain within eyeshot of the drone operator, and to ensure its sensors are precisely aimed it has to be able to 'see' a certain number of ground control points. Another drawback is that with aerial mapping the direction of the drone's sensor must be repeatedly corrected in poorly textured environments (e.g. snow, sand or water). And at ground level, it takes just a tree, bridge or vehicle to block the image. Then there's the problem of ensuring the data collected from the air is compatible and consistent with that collected on the ground.

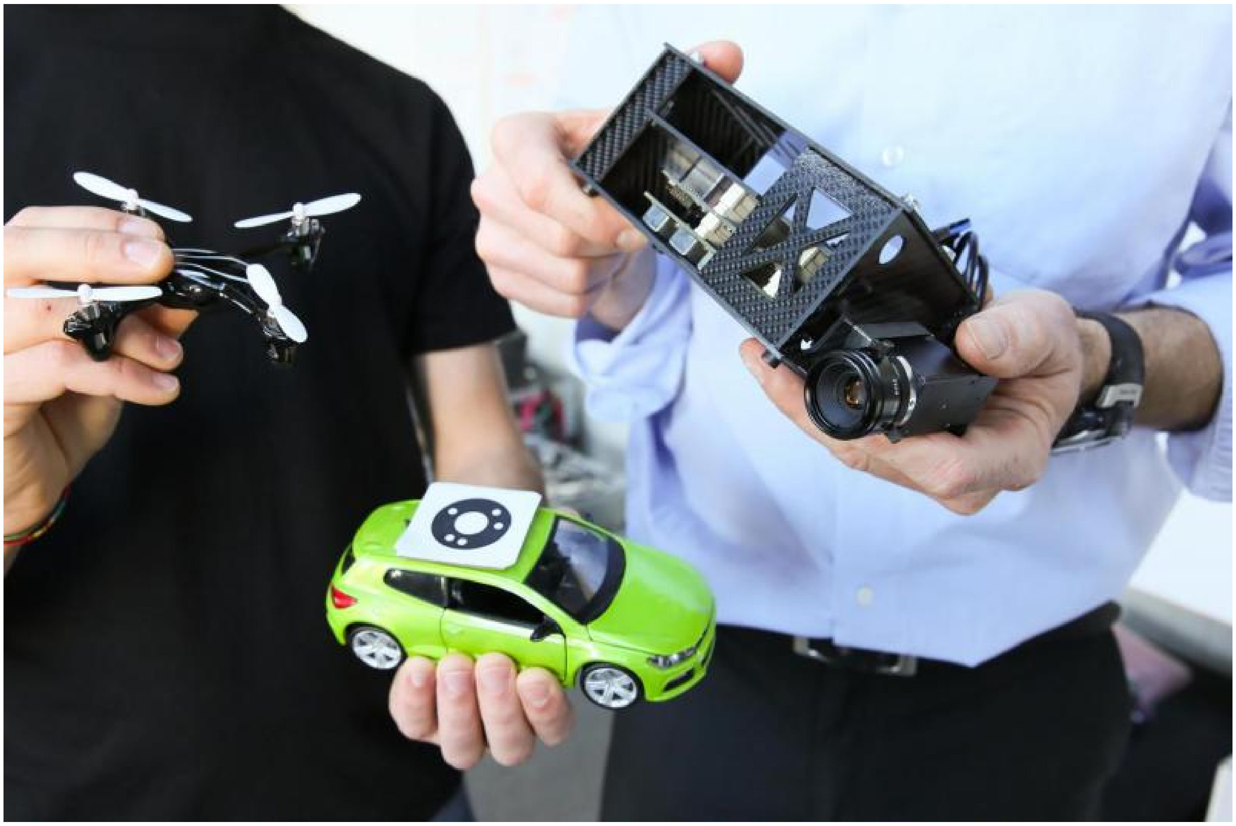
A virtual cord

MapKITE harnesses the advantages of the two techniques – and does away with their drawbacks – by combining them. The researchers equipped the drone with remote detection instruments and a navigation, steering and control system. The terrestrial vehicle, which is manned, also has a real-time navigation system. A positioning system in the vehicle constantly calculates its route while at the same time generating a series of reference points for the drone by converting terrestrial navigation data (time, position, speed and attitude parameters) into aerial commands (altitude and route). This mechanism creates a 'virtual cord' that causes the drone to constantly follow the vehicle and operate at the same scale.

The tandem concept goes beyond just having the drone tail the vehicle. The real value of the virtual cord derives from two features. The first is an optical target developed by EPFL's Geodetic Engineering Laboratory (TOPO). The target is a fractal design attached to the vehicle's roof that allows the drone to optically calculate its distance from the vehicle in real-time (and more accurately during post-processing). This means the drone knows its relative location at all times without using satellite navigation instruments and can conduct data fusion without relying on terrestrial targets. "Through this tandem approach, MapKite also complies with European regulations, since the drone can land autonomously on the vehicle if anything goes wrong or if its batteries need to be changed," said Jan Skaloud, a senior scientist at TOPO.

Galileo, the European global navigation system

The second key feature of the virtual cord is the use of signals from the European global navigation system Galileo – a first at this level of research. Galileo, which went live in December 2016, provides higher quality signals than the American GPS system and offers unique features that reduce errors in calculating terrestrial positions.



Scientists create a virtual attach between a UAV and a terrestrial vehicle. Credit: Alain Herzog/EPFL

In mid-March, the tandem was tested at the BCN Drone Center, near Barcelona. The results were spectacular: the system generated 3-D maps with a resolution of one centimeter, which is much more precise than systems like Google Street View. "With a target that's only 90 centimeters across, the images taken by the drone at a height of 100 meters provides the error in drone-to-target distance of less than 1%, while at a height of 50 meters the error is less than 0.25%," said Davide Cucci, a post-doc at TOPO.

Potential applications for this technology are numerous – especially in map-making, as this instrument can be used to create 3-D models of long corridors. It could also be effective in inspecting and monitoring buildings and other structures in cities. Future developments are sure to emerge as well.

Provided by Ecole Polytechnique Federale de Lausanne

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