Spectacular images thanks to an efficient algorithm

August 7 2017, by Samuel Schlaefli

In the future, drones could simplify elaborate film production such as the James Bond *Skyfall* film (montage). Credit: Keystone / Allpix Press / Cineliz

Filming of spectacular action scenes is expensive and the creative possibilities are often limited. An ETH doctoral student has developed an algorithm that allows drones to implement the desired picture compositions independently.

The film *Skyfall* has its viewers spellbound as James Bond attempts to neutralise his adversary on the roof of a train as it races through the desert. Here, tension is created using a series of rapidly changing camera angles: a close-up of Bond's face, then a medium shot of the fight scene,

and lastly a very long shot of the train, the desert and the two men fighting. This was an extremely expensive scene to film in terms of personnel, materials and technology. Several camera operators were deployed for hours on end at a number of different locations. And a camera crane even had to be mounted on the train's roof for the spectacular close-up shots.

Tobias Nägeli, a doctoral student in the Advanced Interactive Technologies Lab led by ETH professor Otmar Hilliges, is convinced that these scenes can be filmed with fewer resources. Together with researchers from Delft University of Technology and ETH spin-off Embotech, he has developed an algorithm that enables drones to film dynamic scenes independently in the way that directors and cinematographers intend.

Maintaining control of the shooting angle

Drones have been used in filming for a number of years, but good camera shots typically require two experienced experts – one to pilot the drone and one to control the camera angle. This is not only laborious but also expensive. It is true that commercial camera drones already exist that can follow a predefined person independently. "But this means that the director loses control over the shooting angle, as well as the option to keep several people in the image at once," says Nägeli. "That's why we've developed an intuitive control system."

To explain how this works, Nägeli draws an analogy with robotic vacuum cleaners: "We don't specify the exact path that the robot should take. We simply define the objective: that the room should be clean at the end of the process." If we apply this analogy to film, it means that the director is not concerned with exactly where the drone is at a specific point in time. The most important thing is that the final shot meets their expectations.

This process of translation between cinematographer and drone is the job of Nägeli's algorithm. Parameters such as the shooting angle, the person to follow, or tracking shots by the crane and camera can also be defined before the flight. For safety purposes, these parameters are combined with spatial boundaries within which the drone can move freely. The precise path – and the timing of changes of direction – are recalculated by the drone 50 times per second, with GPS sensors providing the necessary data.

Low-cost equipment and an efficient algorithm

For the first proof of concept, Nägeli used a simple drone that is available to buy online for less than CHF 500. The algorithm does not run on the drone itself, but rather on an external laptop that is connected to the drone by radio via a directional aerial. This allows flights with a range of up to one and a half kilometres. "That's sufficient for most applications," says Nägeli.

In a first publication at the start of the year, Nägeli demonstrated in collaboration with researchers from Massachusetts Institute of Technology (MIT) that the drone can perform predefined shots independently, taking into account the image area and the position and angle of an actor within it.

The drone also identifies obstacles and avoids them automatically. For a second publication, Nägeli commissioned film-maker Christina Welter from Zurich University of the Arts (ZHdK) to outline a scene – with a predetermined plot – that would normally require multiple cameras and rails for tracking shots. Nägeli programmed the stage directions into two drones, which communicated between themselves.

In this way, he was able to film shots that are traditionally hard to implement, such as a tracking shot through an open window and filming

with two cameras in a confined indoor space. Through appropriate programming, Nägeli was also able to prevent the drones from flying into each other's shots.

The ZHdK cinematographers were sceptical about Nägeli's innovation; after all, the art of good picture composition is a hard-learned craft. "However, we do not want to replace the director or the cinematographers," Nägeli explains. "Rather, our system is intended to expand the range of tools available to film-makers and allow them to take shots that were previously impossible or extremely laborious."

Use in sports broadcasts and inspections

Nägeli is currently thinking of founding a spin-off to market the technology after he finishes his doctoral thesis, and ETH Zurich has already applied to patent the algorithm. He is convinced that it could be of interest to media and film productions, as illustrated by a research project in collaboration with Deutsche Welle and Italian broadcaster RAI, which is funded by the EU as part of Horizon 2020.

Nägeli thinks that the algorithms could see their first application not in a film studio but in television sports broadcasting; for example, ski races. "This is an area with a huge demand for dynamic shots," says Nägeli. "But manually piloted film drones can present a hazard for the athletes, as we've seen from drone crashes in the past." That is why "spidercams" are typically used today; for example, at the World Ski Championships in St. Moritz. Here, the camera travels along a cable suspended above the athlete; however, this is not without risk either, as demonstrated when a plane collided with the installation in St. Moritz in February. "We are actually doing the same thing as spidercams, but we do it virtually and without cables," says Nägeli. "We can create a virtual flight path that prevents the drone from coming within a minimum safety distance of the athlete."

The algorithms could also be used for inspection of industrial facilities; for example, in the case of wind turbines that are examined for defects using drones. Or for transport purposes: it would be possible to define air corridors that could be used to transport blood or donor organs safely in an emergency. "The drone could identify the fastest and safest flight path independently within this corridor."

Film sets full of drones

Back in the world of film, however, how will this technology change the industry in the longer term? Will scenes lasting several minutes soon be filmed exclusively with drones? "I see no reason why not," says Nägeli. "It's already possible to synchronise 50 drones at once. Using our algorithm, they can all be programmed to shoot precisely the images that the director wants." Would it therefore be possible to film, for example, the heroic battle on the moving train in Skyfall without mounted camera systems and without an army of camera operators? "At present, the algorithm is still in its infancy," explains Nägeli. "But with appropriate investment in the technology and a dedicated team, we could reach that stage in one or two years."

More information: Tobias Nageli et al. Real-Time Motion Planning for Aerial Videography With Dynamic Obstacle Avoidance and Viewpoint Optimization, *IEEE Robotics and Automation Letters* (2017). DOI: 10.1109/LRA.2017.2665693

Tobias Nägeli et al. Real-time planning for automated multi-view drone cinematography, *ACM Transactions on Graphics* (2017). DOI: 10.1145/3072959.3073712

Provided by ETH Zurich