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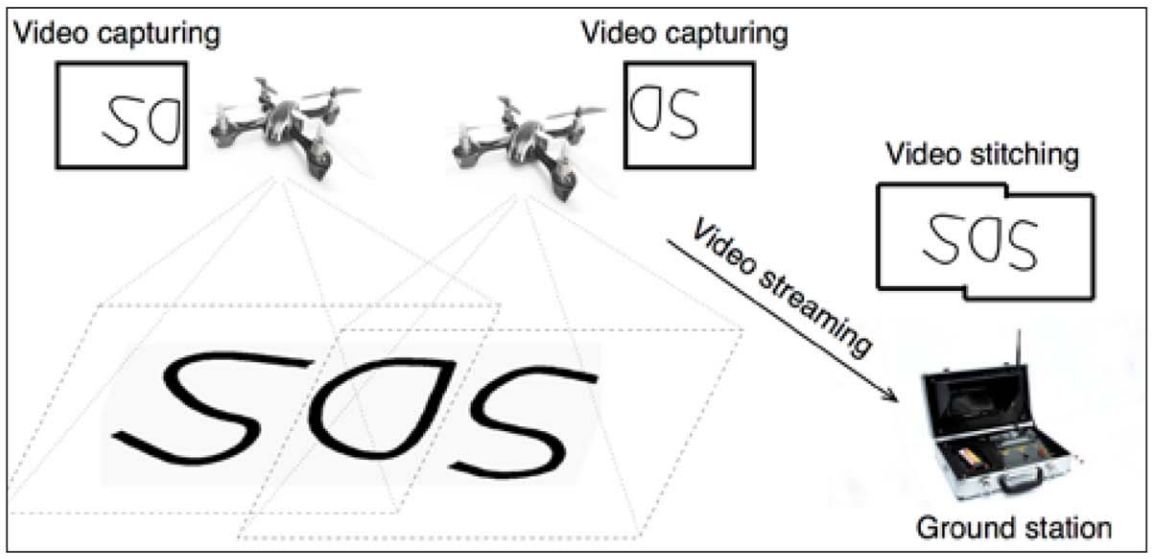
This is the final commentary of a series in TODAY*'s Science section which, in collaboration with the National University of Singapore's (NUS) School of Computing, explores computer science research projects conducted here.*

BEN LEONG

HIGH-DEFINITION VIDEO SURVEILLANCE VIA MULTIPLE QUADCOPTERS

A brand new view via real-time video-stitching



An emerging technology that will change the way we see and interact with the world around us is the unmanned aerial vehicle (UAV). Among these, quadcopters are a common class of flying drones that can be used to take photographs from the air.

Due to their low cost, ease of control and excellent manoeuvrability, quadcopters are widely used by hobbyists and professionals for aerial video and photography.

Recently, they have been adopted for video surveillance applications. For example, camera-carrying quadcopters were recently deployed in earthquake-stricken Nepal to assist ground emergency responders by providing them with a strategic real-time viewpoint from the sky.

It is predicted that the market value for such systems will reach US$2.3 billion (S$3.1 billion) by 2017, up from an estimated US$84 million in 2010.

Our research group at NUS develops novel applications for emerging hardware platforms, and has developed a multi-UAV aerial surveillance system built with quadcopters.

Because cameras have a limited field of view, multiple quadcopters would need to be deployed to cover a large target area. The video streams from the quadcopters would be independent and disjointed, making it difficult to obtain a coherent picture. Thus, it would be helpful if the video streams were combined into a single panoramic video covering the entire target area.

REAL-TIME VIDEO STITCHING

To address this problem, we designed and implemented SkyStitch, a multi-quadcopter-based high-definition (HD) video surveillance system that incorporates real-time video stitching. SkyStitch stitches together multiple video streams from quadcopters to produce a single composite "live" video feed.

SkyStitch is particularly suitable for aerial video surveillance applications that require a large field of view and high resolution.

For example, in search-and-rescue operations, SkyStitch could provide high-resolution panoramic video stream to guide ground emergency personnel searching for injured victims.

In incidents of civil unrest, SkyStitch could potentially be deployed to assist policemen in monitoring the situation and allow them to achieve better situational awareness.

In large sporting events such as the SEA Games or F1 racing, SkyStitch could potentially be deployed to provide HD "live" aerial broadcasting without using helicopters.

A STEP UP FROM EXISTING TECH

Although there are existing panoramic stitching algorithms, current techniques are too slow to be run in real-time. Hugin, a popular stitching software, takes a few seconds to stitch two images or video frames.

One of the key innovations of SkyStitch is that it taps on instantaneous flight information, such as location and attitude, to significantly speed up the stitching process.

To further increase the stitching speed, we divide the workload and distribute some tasks among the quadcopters, each of which has some onboard computational capability.

In this way, SkyStitch is able to stitch 12 HD video frames together within 50 milliseconds and support a video frame rate of 20 frames per second.

As dynamic video stitching is prone to distortions (or artefacts), we also developed a technique to improve video stitching quality.

If the stitched image is not good enough, we try to repair it by predicting the correct stitching using the temporal correlation between video frames. With this approach, the final stitched video is as smooth as that shot by a single camera.

COVERING A LARGER AREA

We constructed a prototype of SkyStitch using two custom-designed quadcopters from off-the-shelf hardware, which are equipped with additional equipment such as a camera, an on-board computer, and a wireless communication module.

We are now working on increasing the number of quadcopters that SkyStitch can support simultaneously. While the current prototype consists of two quadcopters, we would like to eventually support tens of quadcopters so as to cover a large area.

As our prototype becomes more reliable, we hope to eventually test it in real-world rescue operations.

In the long term, we hope the SkyStitch algorithm will be built into commercial multi-UAV aerial video surveillance systems.

While our prototype demonstrates that real-time video stitching is achievable, several important problems still remain, especially in the areas of robotics and wireless networking.

For example, it would be helpful if an algorithm can be developed to have UAVs automatically align so as to maximise the total coverage area without affecting the video quality. We also plan to develop a more efficient aerial-mesh network to increase the communication bandwidth between the UAVs and the ground station. This is very exciting since SkyStitch has the potential to inspire further inter-disciplinary research activities.

The student who developed SkyStitch, Mr Meng Xiangyun, was recently awarded the Final Year Project Innovation Award at the NUS School of Computing. A full paper describing the system will be presented in October 2015 at the ACM Multimedia Conference 2015, a premier international conference.

More information about SkyStitch is available at our website at http://mesh.ndslab.net/home/skystitch.

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HOW SKYSTITCH WORKS

● Each quadcopter transmits a 'live' video stream to a ground station, which stitches the videos together to provide a single composite view of the target area.
PHOTO: DR BEN LEONG'S RESEARCH GROUP

ALL ABOUT SKYSTITCH

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● The system stitches together multiple video streams from quadcopters to produce a single composite 'live' video feed.
● SkyStitch is particularly suitable for aerial video surveillance applications that require a large field of view and high resolution.