Interview with Prof. Davide Scaramuzza

Questions: Marita Fuchs, UZH News

For what research within the field Computer Vision and Robotics did you get the award?

The European Young Researcher Award (EYRA) 2012 recognizes the research I have conducted in the last five years during my PhD and postdoc until the beginning of my professorship in February 2012. The three main contributions which led to this award are in the field of computer vision applied to automotive (i.e., intelligent vehicles) and autonomous micro aerial vehicles.

My first contribution was a toolbox for the popular Matlab software (Matlab is simulation software widely used in all branches of Engineering), which allows users to calibrate wide-angle cameras. These cameras are widely used today in video surveillance, endoscopic imagery, object inspection, and space exploration. My toolbox was the first one developed for the calibration of these cameras and has been made available online since 2006. This tool has become very popular and, besides recording thousands of downloads, it is currently used in several companies such as NASA, Philips, Bosch, Daimler, and IDS Imaging.

The second contribution is in "visual odometry". Visual odometry is the problem of estimating the motion of a vehicle (e.g., a car) from visual input alone (i.e., a camera installed on the vehicle). The successful results achieved by the scientific community in this field in recent years have raised the interest of several companies, such as Navteq, Sarnoff, Google, Daimler, STMicroelectronics, and Volkswagen. The end goal is, on one hand, to boost the precision of GPS navigation systems, and, on the other hand, to enable vehicle localization in GPS-denied environments. For example, think of how many times your GPS car-navigation system gets lost in a city due to poor satellite coverage! Visual odometry, contrary to GPS, does not need satellites to work. In visual odometry, a camera is utilized to look at the scene and to reconstruct the motion of the vehicle by analyzing the changes in the images induced by the motion of the car. This is done by extracting some interest points, such as corners, from the images and matching them across frames. The biggest problem in visual odometry is that this matching procedure is affected by "outliers", i.e. wrong data associations. In order to remove these outliers, there is an algorithm known as "5-point RANSAC" that has become a standard in visual odometry. The only drawback of the 5-point RANSAC is that it is very slow to work on vehicles driving at more than 20 Km/h. My contribution is a “1-point-RANSAC” algorithm that is ten thousand times faster than the "5-point RANSAC", which allows applications at much higher speeds on the road. Furthermore, it is even more accurate. This algorithm works by exploiting the motion constraints of the vehicle, which allow us to predict what the next image should look like in the next vehicle position. This algorithm raised the interest of several companies, such as Volkswagen and Daimler and led to the RobotDalen Scientific Award in 2009, which was sponsored by EU, IEEE, ABB, and Volvo.

My third contribution recognized by EYRA 2012 is for my leadership of the European project SFLY (www.sfly.org), which ended in February 2012. This three-year project focused on the autonomous navigation of so-called “micro helicopters” (about 50 centimeters in diameter) for search and rescue operations in GPS-denied environments. Most of today’s aircrafts and drones rely on GPS to navigate autonomously from point A to point B. However, in absence of GPS, these systems simply do not work (just think of indoor environments or urban canyons where GPS is either absent or not reliable).

Commonly, in these situations, the solution consists of using expensive motion capture systems or laser scanners. The first ones are limited to confined spaces, while the second ones are too heavy to be carried on small helicopters. The contribution that I and the SFLY team brought about was the reliance on solely an inexpensive camera on board the helicopter. This camera tracks interest points in the images and builds a 3D map of the scene (see a video demonstration here: http://youtu.be/_-p08o_oTO4). This map serves as reference for the helicopter and is used to follow a trajectory between two points. The SFLY project ended with a live demonstration in the firefighters training area in Oerlikon on April 2, 2012. There, we simulated a search and rescue scenario where three helicopters had to explore an unknown environment and localize victims.

I believe that autonomous flying robots are the future of robotics and they will be extremely helpful for search and rescue operations (avalanches, earthquakes, etc.). However, in order to accomplish this task, we first need to make them able to work in absence of GPS and lasers. SFLY has greatly advanced the state of the art in this endeavor. In light of what happened in Fukushima in 2011, I believe that these results will have a huge impact on our society since they will allow us to explore disaster environments much faster than with previous technology and, therefore, make immediate and more accurate decisions. Furthermore, this technology opens the doors to many other applications, such as environment monitoring, surveillance, inspection, drug delivery to remote places, search and rescue, evacuation of crowded spaces in high-risk situations, and law enforcement.

What are your main interests, what fascinates you?

My main interest is to build robots that are truly autonomous and have the ability to assist people. This field is called "field and service robotics". In light of what happened in Fukushima and the recent rock fall on the Gotthard rail, the world is in urgent need of robots that can save lives. Most of the robots currently used in these situations are remotely controlled by expert human operators. However, in immediate-emergency situations, it is not always possible to rely on experts already present on the field. This task could be replaced by autonomous or semi-autonomous robots, the latter meaning that even a non-expert human operator would provide high-level commands and the robot would figure out how to do it. As an example, consider the case of a small helicopter that has to be radio controlled by an operator to enter a building in search of victims. As a matter of fact, it is very difficult to pilot such small helicopters; the minimum distraction by the operator could immediately cause the vehicle to crash. However, a semi-autonomous helicopter would process the commands of the operator, so that he only has to provide high-level instructions such as "go 1 meter forwards" or "land here." The robot would then take care of the low-level control, such as the right speed needed for its motor to accomplish the task. During the SFLY press demonstration, for instance, we allowed the journalists to pilot the helicopters using a joystick. Thanks to the intrinsic autonomy of the vehicles, for them it turned out to be very easy to do!

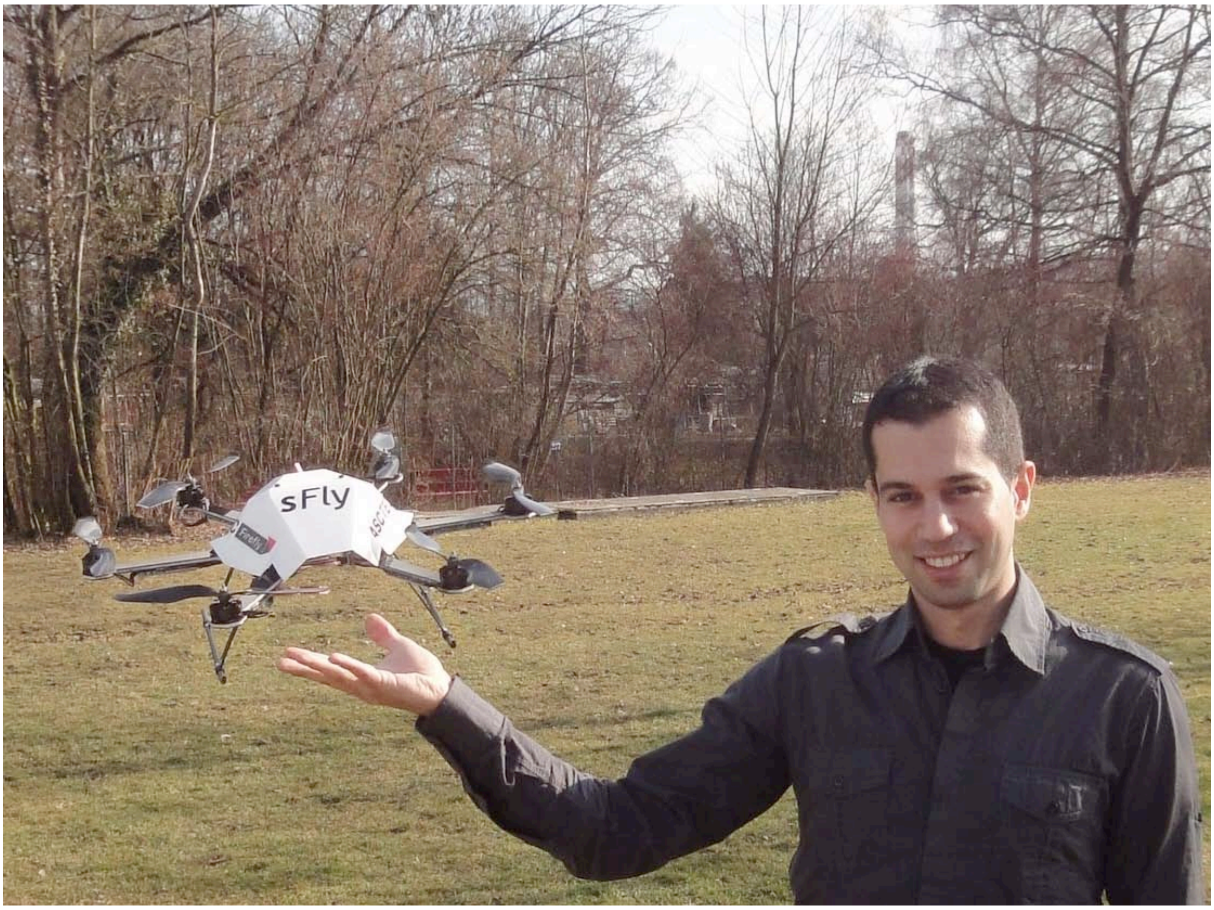
What are your next research projects going to be? Will you continue the work you got the award for?

I will definitely continue working on the research that I received the award for. There are still limitations that have to be addressed and a lot of room for improvements. The future research that I intend to address is on the cooperation among swarms of human, flying, and ground robots. The ultimate goal would be to coordinate efforts of human and robotic rescuers (both flying and ground) to accomplish a certain mission.

Did you receive money with the award or other compensation?

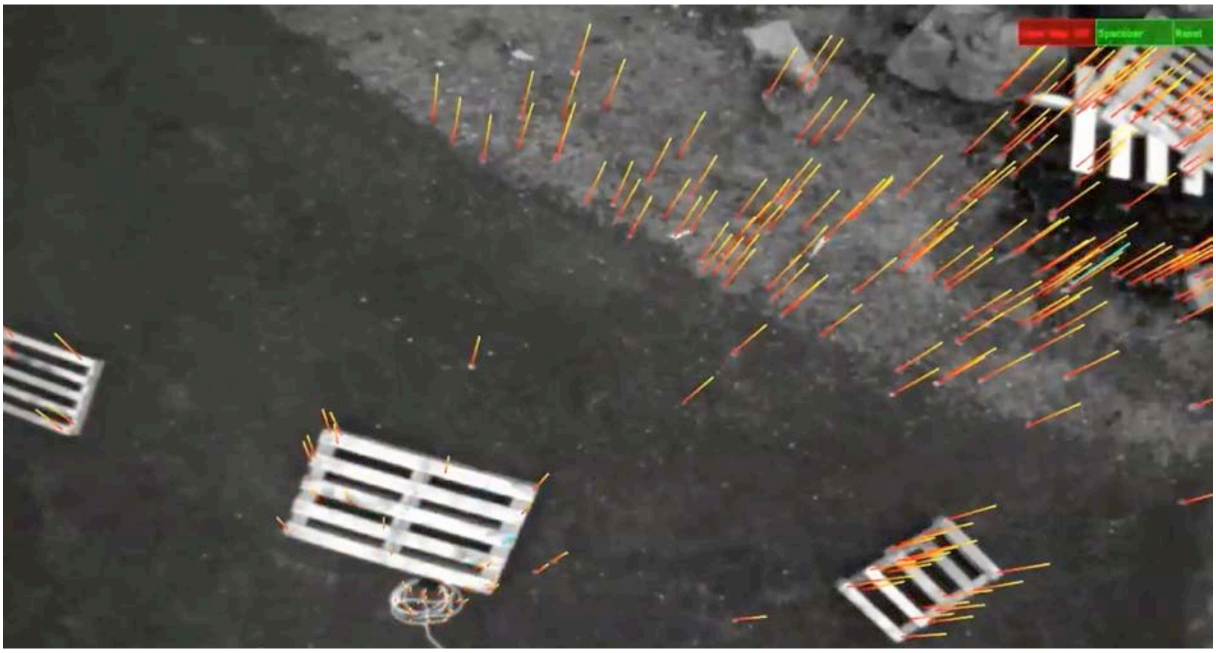
I have been invited to attend the prize-giving ceremony that will be held during the European Open Science Forum in Dublin between July 12 and 15. They have not told me whether there will be a money prize yet.

Could you please send us some pictures of you and your awarded research? (High resolution and if possible landscape format).

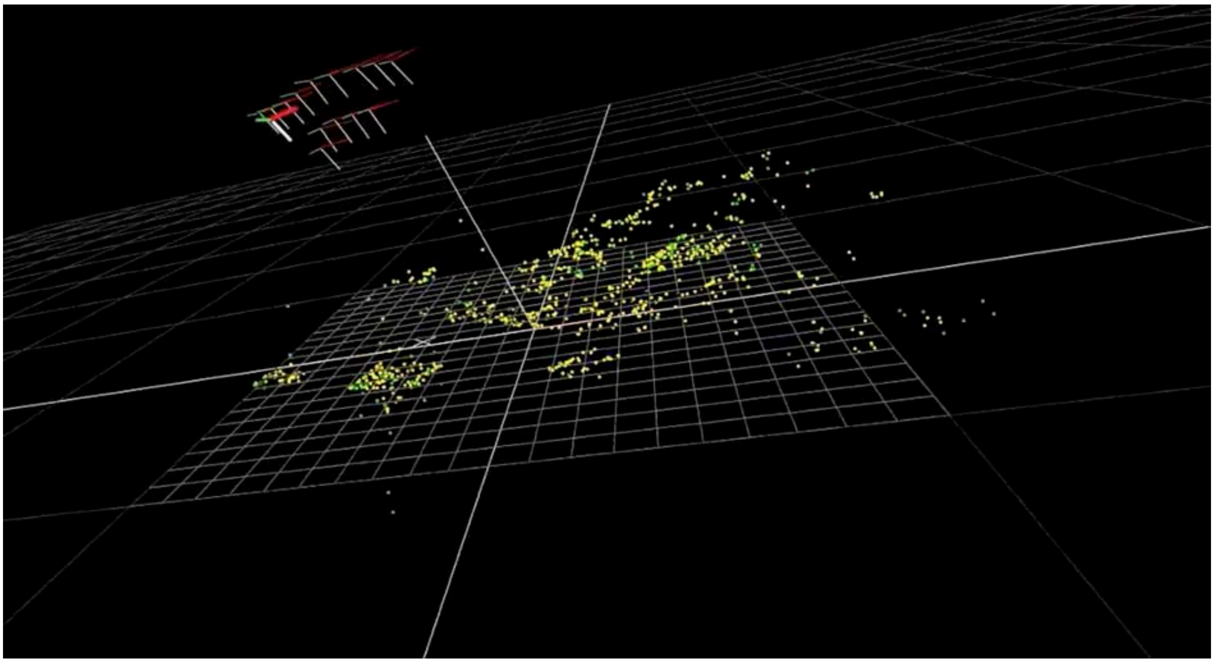


The helicopter used in the European project SFLY

Three autonomous helicopters during the live press demonstration at the firefighters training area in Oerlikon



What the camera on board the helicopters sees: corner features extracted and matched between two frames.



3D map built from feature tracks, which used for navigation.

The vehicle used in my visual-odometry experiments equipped with an omnidirectional camera (top) and estimated motion (bottom, in red) overlaid on Google map