

Smartphones can become the intelligence of demanding robots



August Bjälemark
Hannes Åman Bergkvist

Applications of smartphones

As the number of smartphones grows, as well as their processing power, it is interesting to investigate the concept of combining a smartphone with external hardware. This would enable development of simple and low cost devices that get their functionality and intelligence when connected to the smartphone. If possible, many of the devices at home or at work could be controlled by one smartphone, running an app specialized for the device.

There are many advantages in doing so. It is easier to develop smartphone applications, instead of writing specific low level programming code for each device. It is cheaper since all the devices do not need to include high processing power. It has less environmental impact since the devices can be built with fewer components. It is easy to upgrade by just downloading a new version of the specific application.

Quadcopter

In the project *Quadcopter control using android based sensing* it is investigated if it is possible to control a quadcopter using only the computational power and sensors of an Android based smart phone.

A quadcopter is a flying device with four rotors. By increasing the speed of the different rotors, a torque is exerted on the quadcopter and it will rotate. The sideways movement of the quadcopter is achieved by rotating it so that it is tilted. It will then accelerate in the direction it is tilted.

A quadcopter is an unstable system, meaning that even though all the rotors exerts the same lifting force on it, a small disturbance like a wind breeze will throw the quadcopter off balance. For this reason it requires sensors that measure the angles and a program that uses the sensor data to

compensate for disturbances. Usually some kind of microprocessor and sensors are attached to the quadcopter, but in this project it was shown that it is possible to achieve a good result with a smartphone.

Sensors

The sensors used to determine the angles were a gyroscope and an accelerometer. A gyroscope measures the rate at which the quadcopter tilts. To calculate the actual angle the integration of (cumulative sum) the angular velocity is calculated. This however comes at cost. A slight error, which is always present, in the gyroscope readings will manifest itself as an error that grows over time when integrated (called drift). This is where the accelerometer comes in. An accelerometer measures acceleration and when standing still the direction of gravity. By knowing the direction of gravity, the angle at which the quadcopter is tilted can be calculated. The downside with using the accelerometer to measure the angle is that the measurement is rather noisy and uncertain. If the quadcopter is accelerating the measurement is disturbed even further. By combining readings from the gyroscope and the accelerometer an accurate estimate of the angle can be achieved.

Stabilization of the quadcopter

When the angle is known it is up to the smartphone to process the information. If an angle is smaller than the desired angle, the smartphone ensures that the angle increases by providing the appropriate current to the motors.

The amount of current it should provide is calculated with a PID (proportional – integral – derivative) controller. It is an algorithm that is divided into three parts (P, I and D). The difference between the desired angle and the actual angle is the error. The P part calculates a value proportional to the error. The I part calculates a value proportional to the integration of the error. The D part calculates a value that is proportional to the rate of change of the angle. These three values are then added together and the current the motors should receive is proportional to this value.

Remote control

To enable an operator to control the quadcopter, a joystick was implemented to a computer program. By tilting the joystick, a desired angle is set for the quadcopter. The communication is performed via a wireless network, for example a wifi connection or 3G. The smartphone is also able to take photos and send them in real time to the operator. In this way, it is possible to control a quadcopter from a far distance.