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Could you work with a robot?

A next generation robotics upsurge is underway. And it surrounds the transfer of the robot from its traditional role undertaking assembly line activities, into a new world where it may undertake varying tasks and have to work alongside human beings.

Could you work with a robot? Or more importantly, could a robot work with you?

The media seems to enjoy sensationalist headlines and therefore focuses on robots taking away human jobs or robots collaborating together at the expense of humans. But of far more interest and relevance is the possibility of collaboration between robots and humans.

The potential for human-robot collaboration demands rather different things of the robot than its traditional setting. Robots are no longer in safe environments, performing the same unvarying task over and over where their strong-points of speed, accuracy, and strength ensure their success. They are starting to move into semi-structured environments where they have to perform varying tasks and interoperate with different objects and most importantly humans.

For robots to be able to operate in this new world, they need to be highly aware of their surroundings and be able to collaborate. They may have to work remotely and therefore be optimized for low power environments. Similarly, in some of the areas, they are being envisaged, they are only viable at a certain price and so cost-effectiveness is key. To move into these varying worlds they also need to be relatively easy to use and not require extensive, specialist resources to make them workable.

The use of Kiva robots, in Amazon's new fulfilment centres, is a good example of robots and humans co-working. Robots now operate alongside human workers in the warehouse in order to fulfil customer orders. With the advent of sales initiatives such as Black Friday, the huge surges in demand need to be met by flexible order fulfilment operations and the usage of this new generation of robots is allowing Amazon to do just this. Humans work alongside robots, safely and effectively.

All of this means that the role of sensor technology to help robots perceive their world through imaging, acoustics, and tactile-sensing is critical. Fortunately, sensor technology has been moving on significantly in the last few years and there are some very exciting developments predicted on the horizon.

The five technologies I'd like to introduce you to are:

¬ Time of Flight cameras

Time of Flight (ToF) cameras are the latest incarnation of quasi-3D imaging, providing depth data in a 2D image. They use different technology for creating a 3D picture and the way in which they operate is advantageous for various robotic applications.

ToF cameras have two main components: a light source and a camera. They operate by pulsing light from the source and then measuring the amount of time it takes to capture the object in the camera – the different time lags provide the distance to the object. This means that they are able to create a picture of what's near and what's far. ToF has an affinity for the robotic world because it has some key advantages.

It is very fast – providing up to 160 images per second – which clearly for robotics is key. It reduces algorithmic complexity considerably, meaning that a powerful microprocessor is not required just to operate the camera. In addition it is much easier to use, not needing teams of software designers to integrate it. The key parts ToF cameras contain are integrated circuits and these are now available from multiple manufacturers, therefore the unit cost is starting to fall as the market increases. The size of the unit also makes it reusable in lots of applications.

The ability to be able to perceive distance through using depth data allows robots to make far more robust decisions than those made using contrast data alone. This is very helpful for robots needing to handle different objects at different distances and to avoid collisions with other objects. Warehouse type work, palletising and de-palletising packed objects of similar colour and design sitting one on top of the other, are more easily broken down by using depth data than by trying to distinguish them using contrast.

¬ Hyperspectral imaging

Hyperspectral imaging is another vision-aid for the robot. Hyperspectral imaging takes photos of things in a very narrow band of the colour spectrum. That narrow band can be in any part of the spectrum including the non-human visible ranges of infra-red and ultra-violet. The visual spectrum is roughly from 400 to 700 nanometres (nm) and hyperspectral imaging can take slices of less than 1 nanometre. This means that hundreds of pictures of the same thing at different wavelengths can be taken to reveal features that are not feasible when the light is simply binned into the broad wavelength bands of red, green and blue. There are some interesting images that can be viewed on the NASA website of hyperspectral imaging of the world.

The reason for producing images at different points on the spectrum is that at different points different things are visible. It is possible to detect changes in optical phenomena such as absorption, transmission, scattering, fluorescence, luminescence and interference. The technology can be used for both inspection and identification and in spheres such as monitoring crop condition, tracking pollution, and biomedical diagnostics.

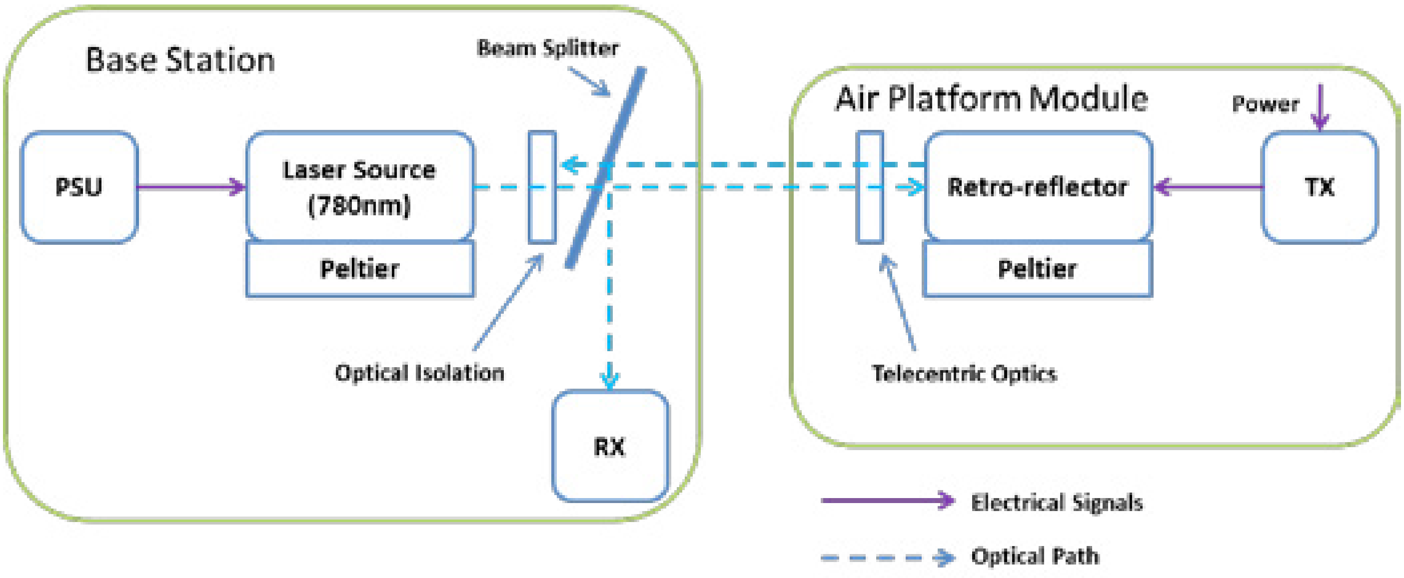
Hyperspectral cameras are complex, often involving moving parts to select the wavelength of interest. There have been advances in imaging chips more recently which provide multispectral imaging. These do away with the complex wavelength selection optics and instead place wavelength filters directly on the imager chip. While these are not capable of the same spectral resolution (e.g. 32 wavelength bands rather than hundreds), the cost and complexity is greatly reduced bringing the hyperspectral technique to new applications.

Robotic surgery, for example, can take advantage of this technology. Using hyperspectral imaging it can become possible to distinguish bone, blood, tissue etc by colour and with intra-operative imaging guiding the robot, very accurate surgical procedures can be undertaken.

¬ Retro-reflective communications

Retro-reflective line-of-sight optical communications work with two modules: a laser transmitter/receiver and a reflector. The reflector is the interesting bit; it contains a modulator and a reflector and its job is to reflect back to the laser source modulated light. Because it reflects the light rather than transmits it, it doesn't need a heavyweight power source. It needs power purely to run the modulation unit but the energy itself is reflected. This means that the reflector (modulating retro-reflector) can communicate optically over long distances without needing substantial on-board power supplies. The retro-reflective approach is capable of very high-bandwidth (e.g. 4x HD video channels) at very low power consumption compared to an Radio Frequency (RF) solution.

The diagram below shows the architecture at a high level:



Source: Sagentia

¬ Inductive sensing

Inductive position sensing has a history in the defence and automotive sectors and a reputation for robust and accurate sensing systems. Yet they tend not to have been used more widely. This is largely because the technology underpinning inductive sensing – wound coils and metal parts – has made them relatively expensive (>$200USD) and bulky.

The next generation of these sensors using printed circuit boards has brought the size and the cost down – to somewhere around the 2 dollar mark – and it can now been found in driver controls, such as the accelerator pedal, used in mass-produced cars. Using this PCB technology it is possible to make not only linear and rotary sensors but also complex curvilinear paths. The electronics can also be mounted on the same board to save space and reduce the number of connections.

A key benefit of this inductive sensing technology is that it is non-contact and can be used in very demanding environments where optical techniques would fail. Being a non-contact technology, the two halves of the sensor can be separated and brought back together, offering the possibility of exchangeable tools or extremely long ranges of movement with localised sensing.

¬ Tactile sensing

While optical sensing and inductive sensing are non-contact processes, tactile sensing – one could even use the human term "touch" – is also a key way of perceiving one's surrounding. A classic example is the use of touch in surgery. Yet faithfully replicating the sense of touch in a robot is very, very hard to achieve. Can allowing robots and humans to collaborate symbiotically enable robots to use the human natural sense of touch? What if we could digitally transmit, share and analyse the sensation of touch and texture to the finger tips?

This is where the discipline known as haptics is heading. It is able to externalize the sense of touch and so is able to communicate it to a remote object. For example, the robot could touch something and transmit the sensation to the human operator, who might be local to the procedure or very remote.

This all sounds very complicated and expensive. Surprisingly however useful tactile feedback can be provided relatively simply and at a low-cost. This is because it does not have to be perfect. The sensory feedback you need to provide is that which is needed for control. The feedback doesn't have to be "perfectly transparent", that is it doesn't have to replicate the human experience exactly. We have found that once you give a human haptic feedback they are brilliant at learning the dynamics of the system. This is an intuitive process.

As part of their Robot Revolution focus Sky News conducted a survey asking people if they could love a robot. To the question "could you have a fulfilling emotional relationship with a robot?" 15% of men answered yes. Undoubtedly this says more about men than robots. But this question illustrates the interest in the possibility of co-existing with robots as part of our daily lives. To co-exist happily we need to collaborate and we can only do that with highly aware robots. The recent advances in sensor technologies – allowing robots to adapt to a changing and less predictable environment, and to perform tasks that are increasingly valuable to human beings – should help us move to this new modus operandi safely and effectively.

Footnotes

[1] Institute for Global Futures: top 10 robotics trends http://www.globalfuturist.com/about-igf/top-ten-trends/top-ten-robotic-trends-for-the-21st-century.html

Forbes: http://www.forbes.com/sites/haroldsirkin/2015/07/15/robots-the-next-industrial-revolution/

The Economist: http://www.economist.com/news/leaders/21599762-prepare-robot-invasion-it-will-change-way-people-think-about-technology-rise

[2] http://www.businessinsider.com/market-forecast-and-growth-trends-for-consumer-and-office-robots-2014-5?IR=T Still, worldwide sales of robotics hardware in 2013 increased 12 percent year over year, to $9.5 billion, according to the International Federation of Robotics. The federation estimates that, including the cost of software, peripherals and systems engineering required by the hardware, worldwide sales were $29 billion.

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