COMPUTER graphics is a dynamic and rapidly evolving field. Right from your desktop monitor, to your video games to watching 3D movies, everything involves computer graphics. Much has happened in the field of computer graphics in the year 2017. Let’s take a look at some of these developments.

Ultrafast Camera
First up is the development in technology for self-driving vehicles and drones. A new ultrafast camera for drones and self-driving vehicles has been developed at the Nanyang Technological University, Singapore.

Assistant Professor Chen Shoushun from NTU’s School of Electrical and Electronic Engineering has developed a new camera named Celex. He unveiled the prototype of Celex in February 2017 at the International Symposium on Electronic Imaging (EI 2017) held in the United States. It received appreciation from the conference attendees.

The research into the sensor technology started in 2009. It has received a funding of $500,000 from the Ministry of Education Tier 1 research grant and the Singapore-MIT Alliance for Research and Technology (SMART) Proof-of-Concept grant.

The technology was also published in two academic journals published by the Institute of Electrical and Electronics Engineers (IEEE), the world’s largest technical professional organisation for the advancement of technology.

Conventional optical cameras used in drones can be blinded by bright light and are not able to figure details in the dark. The new smart camera developed by NTU can record even the slightest movements and objects in the real world.

The new camera is much faster than conventional video. It only takes nanoseconds to record the changes in light intensity between scenes. The data format in which the images are saved is much smaller too. The camera does an instant analysis of the captured scenes, highlighting important objects and details.

Normal optical cameras can see very far objects but the video feed takes time to process. The new camera overcomes this drawback. The time required between the analysis and the processing of the image is very less. It also has a continuous...
tracking feature. All this makes it faster and a great safety tool for self-driving vehicles. It helps drones and other autonomous vehicles avoid collisions that can take place within a few seconds.

Optical cameras record up to 30 frames per second. However, the high-speed video cameras used in Celex record up to 120 frames per second. The data generated by these cameras is in gigabytes, which is then processed by a computer for self-driving vehicles to view and analyse their environment.

As the complexity of the environment increases, the computer takes more time to process the video data. This leads to more time difference between the receiving of the picture and the response of the vehicle to it. To reduce this time lag, a new algorithm in computer graphics has been used to capture the image. The new camera takes individual pixels at its sensor and records the changes in light intensity between them. This does not require the whole visual image to be taken as a photograph, thus increasing the camera’s processing speed.

The camera sensor has a new feature called the built-in processor that can analyse the flow of data at the very instant. This enables the camera to differentiate between the foreground objects and the background. The technology used is optical flow computation. Thus, self-driving vehicles now have more time to react to imminent obstacles. The camera also has the potential to be used for security and surveillance, as well as for robotics such as in robots that are programmed to do cleaning work.

With keen interest from the industry, Prof. Chen and his researchers have spun off a start-up company named Hillhouse Tech to commercialise the new camera technology. The start-up is incubated by NTUitive, NTU’s innovation and enterprise company. Prof. Chen expects that the new camera will be commercially ready by the end of this year, as they are already in talks with global electronic manufacturers.

3-D Holographic Displays
Next is the recent development of a new methodology for 3-D holographic displays that hugely improves the image quality.

Holography was initially regarded as an analog technology. Digital imaging and display computing opened new doors for holography. The potential applications of digital three-dimensional holograms are huge. Different fields such as entertainment, arts, biomedical image visualisation, engineering drawing technology could benefit from the science of 3-D digital holograms. However, the applications remained limited because of the constraints on hologram generation technology.

Recent research in the Physics Department of the Korea Advanced Institute of Science and Technology has managed to come up with a solution and developed a 3-D holographic display that does more than 2600 times better than the existing holographic displays. The major problem with current holographic displays was the restricted viewing angle and size of the 3-D images. This study done by a research team led by Professor Yong Keun is expected to improve on both these limitations. The study was published online in *Nature Photonics* on the 23rd of January 2017.

In order to create a three-dimensional hologram that can be seen by the human eye without using any kind of special equipment such as 3-D glasses, the wavefront of light must be kept within limits and controlled using wavefront modulators like spatial light modulators and deformable mirrors. A wavefront modulator is a device used for optical manipulation that can control the direction of the propagation of light.

However, the main problem with using wavefront modulators is the pixel number. The large number of pixels that are packaged into high-resolution displays made in recent years are good for a two dimensional image, but the amount of information contained in them is not enough to produce a 3-D image. This is the reason why a three-dimensional image that can be developed with the existing wavefront modular technology is only 1 cm in size with an extremely narrow viewing angle of 3 degrees, which is not practical at all.

So, KAIST researchers added two successive holographic diffusers for light scattering. The light scattering in different directions gives a bigger viewing angle and a bigger image, it however results in volume speckle fields, which are caused by the interference of multiple scattered light. These random fields cannot be used to display 3-D images.

In order to solve this problem, the researchers employed a wavefront shaping method to control and limit the fields. Thus, they succeeded in developing an enhanced three-dimensional image with a viewing angle of 35 degrees in a volume of 2 cm in length, width, and height. This produced a result that was 2600 times better than the original image definition.

This approach has made possible 3-D displaying...
technology wherein 3-D displays can be enjoyed without the need for special glasses. This technique can also be applied to the concepts of Virtual Reality and Augmented Reality to enhance the image resolution and viewing angles.

3-D X-ray Imaging

Another development relates to the application of 3-D X-ray imaging to a microchip that makes the finest details of a microchip visible.

A microchip (also referred to as an Integrated Circuit or a chip) consists of wires and several transistors. These transistors act like switches and are responsible for the flow of electricity in a microchip. Instead of being activated by finger movements like normal switches, a transistor is activated with the use of an electric signal.

Today, microchips are found in almost all electronic gadgets. They are smaller than our fingernails and are used to store information, perform logical operations and can also be used as microchip implants. Because of its various uses, it is necessary for a microchip to meet up to its specifications.

To analyse the chip’s performance we need to visualise its small internal parts (transistors), which cannot be done normally as their size varies in nanometres. The wiring in most of the microchips is 45 nanometres wide while the transistors are 34 nanometres high. Due to its small size it is a challenge to check the chip in detail without destroying at least a small part of it.

To handle such issues to some extent, manufacturers have been examining the chip layer by layer with the use of an electron microscope. This method is known as focused ion beam or Scanning Electron Microscope imaging (FIB/SEM). But this method consumes a lot of time, may cause damage to the microchip, does not avoid distortion of images if the layer is not planar and it cannot be used to analyse the whole chip together.

To overcome these disadvantages, researchers at the Paul Scherrer Institute have come up with a new method that uses X-rays for the 3-D images of a layer in a microchip.

The conversion of X-ray images to 3-D images is done using computer graphics. This is the first time a non-destructive method has been devised to visualise the internal parts of a chip. It is used to observe the wiring paths and transistors of a microchip without destroying or deforming any part of it. The 3-D images formed after scanning with the X-rays are used to analyse the chip.

In experiments conducted by the researchers, a small piece of the chip has been examined without any deformation using a method (a special tomographic method) that the researchers have been developing for quite a few years. In this method, the projection of the images is done using a light source offering the world’s best resolution of 15 nanometres.

The object to be visualised is X-rayed at a few predefined positions with light from the Swiss Light Source of the Paul Scherrer Institute. For every illuminated spot, the X-ray light pattern is measured by a detector and is projected on the screen as a 3-D image. The object is then rotated at small angles and the X-ray process is repeated again for every rotation. From the data acquired, a 3-D image can be projected with high resolution.

How is the 3-D image projected? To convert the X-ray (2-D images) into 3-D images, computer graphics is used. 3-D images can be converted to 2-D images using projection but the same cannot be done for converting 2-D to 3-D images. For this, we use the methods like Cone beam projection. This method uses 2-D data and a light source along with a separable footprint projector for obtaining the 3-D image.

Even though the whole chip cannot be visualised at once using this method, the chip remains undamaged and we get a perfect 3-D structure. This also avoids distortions and deformations that arise in FIB/SEM.

Gabriel Aeppli, head of the Synchrotron Radiation and Nanotechnology Division at the PSI wants to develop the method in such a way that it can examine the whole microchip within the stipulated time. Then the chip can be studied several times from different angles.

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