Photonic Computing

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Light reflects off everything, emitting a colour. Humans and animals also send and receive colours with specific meaning, making it the world's biggest communication medium. In the natural world, light is used for data processing and calculations. But what if we applied the same use colour for data processing and calculations in the artificial world?

Photonic computing refers to using light to represent data and to do computer operations. Light can replace traditional binary representations to perform these tasks. That is, light can be decomposed into various colours that make up the colour spectrum, and these colours can be used for the above purposes.

In digital computers, a byte consists of 8 bits and is used to signify a character such as 'A', '9' or '#'. This is done using an 8 bit binary code of '0s' and '1s'. A byte of 8 bits can furnish 256 or 28 patterns. Therefore, a byte can store a number between 0 and 255 for numerical values.

A binary representation of characters fits in neatly with the use of 'on/off' switches found in integrated circuits. Here the 'on' state with the switch represents the digit '1' and off the digit '0'. As the number of bytes used for the numeric representation of data increases is size, the underlying binary representation becomes arithmetically large. Therefore, large numbers written in binary form require significant storage capacity.

In contrast, the use of light to represent data provides the opportunity for multidimensional, parallel, compact and high speed data storage and computations. This arises because data can be represented in five dimensions that describe light including colour (i.e. red, green and colours plus brightness and saturation.

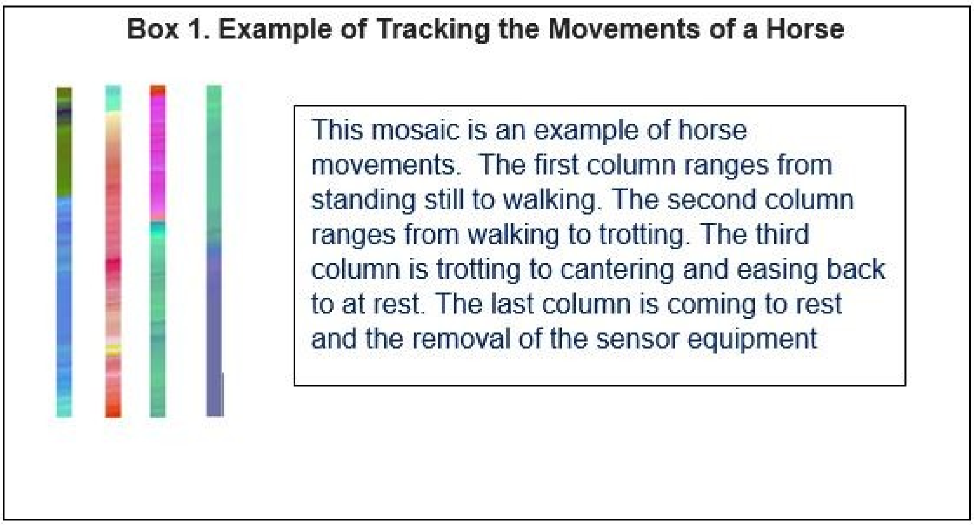
When it comes to optical data storage, researchers at three Australian u demonstrated a novel and energy-efficient approach to storing data usi developing technology based on nanocrystals with light-emitting prope efficiently switched on and off in patterns that represent digital inform use lasers to alter the electronic states, and therefore the fluorescence p crystals. These fluorescent nanocrystals could represent a promising al magnetic and solid-state data storage.

When it comes to calculations and transformations using light, one pos use the equivalent of logarithms where numbers are transformed into lo mathematical operations are performed on the numbers such as additio the results are converted back to numerical results. From another persp drew attention to solving 2D mathematical equations using colour. He a clever way of representing vectors, and can be applied to complex nu

Two examples where light can be used to represent data include: tracki entities such as people, animals and cars; and the encryption of messages.

Tracking Movements

When movements are being mapped, a photonic approach gives 16,777,216 [4] different three dimensional (3D) positional data points using red, green and blue hues. This creates a mosaic pattern where the movements are represented as single colours. When multiple observations are taken and are visually examined, rhythmic patterns and positional variations within those rhythmic patterns can be identified.



For the above example in Box 1, a 3D sensor was mounted on a horse and then the horse was ridden around a set course for a specified time. Using this approach, it is possible to identify specific way points and any variations in the horse's movements. This data could be used to identify any anomalies in the horse's gait, which could indicate possible lameness and the degree of this problem. If a regular starting point could be estal repeated occurrences, as shown in the example in Box 1.

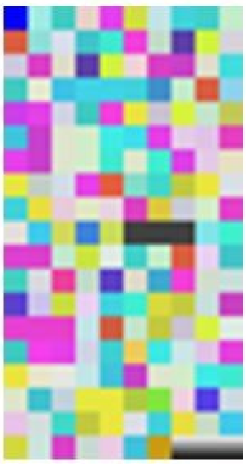
Encryption of Messages

With a photonic approach it is possible to compress and store data in a[…] allows it to be transferred and accessed from an image file rather than […] In the example in Box 2, there is a coloured pattern representing the L[…] Christian Bible. It has been transformed and compressed from text to a[…] one tile contains three pieces of data. However, the image can have a n[…] made to make it harder to decode and read. By changing the colour co[…] as changing a red, green and blue to a blue, red and green sequence, or[…] weighting factor, the message within the image is encrypted and canno[…] without the key.

This mosaic is of a single piece of text repeated twice. The before the t[…] the standard text. Following the three black squares is the same text bu[…] Each square has a possible 16,777,216 possible combinations of chara[…]

The message can also be encrypted before being converted into an opti[…] would make it many times harder to decrypt.

Box 2. Encryption of the Lord's Prayer



This mosaic is of a single piece of text repeated twice. The before the three black squares is the standard text. Following the three black squares is the same text but slightly scrambled. Each square has a possible 16,777,216 possible combinations of characters.

Other Applications

The above examples illustrate that there are potentially many practical uses of a photonic approach to computing; it can be used to store and transmit compressed and encrypted data; it can track the movements of people, other animals and mechanical objects; and it can identify their colour signatures. This can assist with safeguarding data from unauthorized intrusions, with controlling traffic flows, with teaching intricate and highly skilled movements in sports such as with tennis shots and with detecting criminals, terrorists and similar where a photonic detection is used with facial recognition [5]. It can also assist with measuring the nutrients, moisture and pesticides in agriculture fields, and with diagnosing diseases based on their spectral patterns. The potential uses of photonic computing are many.

authentication of users. Malicious actors now have access to increasing capabilities that threaten governments and private enterprise. An exam character password consisting of upper and lower case numeric and no This takes less than 500th of a second using a high-end video card fror [6]. They offer much more processing power than many desktop perso

Using a photonic approach to certificate-based authentication could pr certificate that changes colour every time it is accessed, in a similar ma [7]. It can authenticate users who have a corresponding photonic certif permutations here are many thus making it difficult for malicious actor these certificates. The certificates could also decide what access privile conferred based on the contents of his/her photonic certificate, and the cover. This too has to be tested to see if these expectations are supporte

Photonic versus Quantum Computing

It is also considered that photonic computing could fill the gap betwee computers and the promise of quantum computers. Quantum computin mechanical principles to perform numerical operations. They would th solve certain problems much more quickly than any classical computers that use even the best currently known algorithms.

Quantum computers [8] promise to run calculations far beyond the reach of any conventional supercomputer. They might revolutionize the discovery of new materials by making it possible to simulate the behaviour of matter down to the atomic level. They could upend cryptography and security by cracking otherwise invincible codes. There is even hope they will supercharge artificial intelligence by crunching through data more efficiently.

Photonic computers will not process numbers at the super speed of quantum computers, but they offer the possibility to outperform conventional computers in data processing and scientific calculations. They can do this without the current technical complications of quantum computers that are very sensitive to temperature and other environmental conditions.

It is added that a tri-coloured light emitting diode (LED) commonly used as light bulbs, when used as a transmitter and a light variable resister (LVR), or when used as a receiver behind a single colour pass filter, can be employed to build a photonic computer. Any school child using a basic electronic kit 'such as Arduino or Raspberry Pi' purchased online can do this. We even have an app Android app called APIAR that can do photonic operations.

The future may see the progression of digital computers, photonic computers and quantum computers with each having a particular strength and each having a particular niche where they perform best.

Conclusion

The potential of photonic computing is considered immense. These computers could confer many possible advantages with storage, transformation and transmissic

and the provision of privileges. The next steps are to see to what exten
can be realised. As suggested above, these computers could fill the gap
computers and the great promise of quantum computers.

Notes

1. Other contributors include Tony's wife Emily, Stewart Turner, Ga
Palmer and Warwick Graco

2. N. Riesen, X. Pan, K. Badek, Y. Ruan, T. M. Monro, J.Zhao, H. E
and H. Riesen (2018)Towards rewritable multilevel optical data storag
nanocrystals. **Optics Express, 26, 9, 12266-12276.** •https://doi.org/10

3. See https://hackaday.com/2018/03/26/solve-2d-math-equations-c

4. Each pulse of light that is made up of the three basic hues of red,
represent a number between 0 and 16,777,216. That is,256 (red hue) *
(blue hue) = 16,777,216 or 224 colours

5. https://en.wikipedia.org/wiki/Facial_recognition_system

6. https://en.wikipedia.org/wiki/Video_card, https://computer.howstuffworks.com/graphics-card1.htm, https://en.wikipedia.org/wiki/Graphics_processing_unit and https://www.techspot.com/community/topics/cracking-passwords-using-nvidias-latest-gtx-1080-gpu-its-fast.229218/

7. https://en.wikipedia.org/wiki/Blockchain and I. Bashir (2017). Mastering Blockchain. Packt Publishing, Ltd and D. Tapscott and A. Tapscott (2016). Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business and the World. London: Portfolio Penguin

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Hi Tony,
There were articles a few years ago which discussed using light in processors insteac
currents to reduce the heat generated, power consumption and step up the speed o
the number of channels available in the bus relates back to the possible number of c
with this article. Here is a link which discusses the use of light in processors.

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