Global Panopticon

Professor Chris Chatwin

School of Engineering & Design
University of Sussex

IET – The Hawth, Crawley – 8th October 2009
Summary

Credits: Young, Birch, 2020 Imaging Ltd

Panopticon since 5000 BC – It’s a mental state

Contemporary Panopticon Infrastructure & Technologies

Video Surveillance

Biometrics

Label technologies

Conclusion
How was it done in the past? The all seeing eye of God

Imagery of an all-seeing eye can be traced back to Egyptian mythology and the Eye of Horus.

Horus the Falcon God of the Sky – Egypt 5000 BC
The all seeing eye representing the eye of God keeping watch on humankind

Christian icon of the Eye of Providence or the all seeing eye of God

A 1525 Jacopo Pontormo painting using the Eye of Providence in a triangle as a symbol of the Christian Trinity.
The Eye of Providence can be seen on the reverse of the Great Seal of the United States, seen here on the US $1 bill. An all-seeing eye that appears on the tower of Aachen Cathedral.
Jeremy Bentham's design for a 'panopticon' style prison.

“Bentham laid down the principle that power should be visible and unverifiable.

Visible: the inmate will constantly have before his eyes the tall outline of the central tower from which he is spied upon.

Unverifiable: the inmate must never know whether he is being looked at at any one moment; but he must be sure that he may always be so.”
French philosopher Michel Foucault described the implications of 'Panopticism' in his 1975 work *Discipline & Punish: The Birth of the Prison* --

“Hence the major effect of the Panopticon:

to induce in the inmate a state of conscious and permanent visibility that assures the automatic functioning of power.

So to arrange things so that the surveillance is permanent in its effects, even if it is discontinuous in its action;

that the perfection of power should tend to render its actual exercise unnecessary.
Global Postioning System – a fundamental element of the Panopticon

24 spacecraft in 12 hour circular orbits, with 3 on-orbit spares. Six circular orbital planes, R=26,560km

GPS User: Horseback Biologist in Amazon
What or Where is the Modern All Seeing Eye?

Scientia est Potentia, Latin for Knowledge is Power
Space Surveillance Network

Worldwide Network of 20 Optical and Radar (Mechanical & Phased Array) Sensor Sites
Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) - Diego Garcia / Maui / Socorro

• Primary Mission: Space Surveillance
• Supports Air Force Space Command (AFSPC) as a dedicated Deep Space (DS) sensor
• GEODSS brings together the telescope, low-light-level cameras, and computers
Space Surveillance

- Conduct space surveillance from space
- Surveillance of entire geosynchronous belt
- Assured access to objects of military interest

NAVSPACE Fence

- Provides up to date satellite orbital elements to Fleet and Fleet Marine forces
- Supports US Space Command as part of nation’s worldwide Space Surveillance Network
Ubiquitous Sonar Surveillance Systems
Satellite Image of Military Vehicles
Pentagon Repairs

One-meter resolution satellite image of the Pentagon reconstruction progress was collected on Nov. 20, 2001 by Space Imaging's IKONOS satellite. An interior section of the Pentagon has been removed so that reconstruction can proceed.
MST’s sonar systems are able to accurately identify small submerged objects such as discarded evidence or corpses, making it ideal for law enforcement investigations.
Sonar Systems

Thales CAPTAS - Combined Active / Passive Towed Array Sonar - is a family of low frequency variable depth ASW sonars for surface ships.

MST’s sonar detection systems can accurately image small underwater threats such as mines.
Satellite Communication Systems Integrate into the Global Fibre Backbone
A graduate of Woolwich Polytechnic won the Nobel Prize for Physics yesterday. Charles Kuen Kao’s work with fibre optics paved the way for lightning-fast broadband. Professor Kao was honoured for his breakthroughs involving the transmission of light in fibre optics.

He was the first person to develop efficient fibre-optic cables and as a result of his work more than a billion kilometres of optical cables carry super-fast broadband internet data to and from households and offices around the world.
DWDM Optical Fibre Communications
- Capacity: 7.1 terabytes per second Dec 2007

Fundamental element of Panopticon

The internet's undersea world

[Map showing submarine cable systems around the world]

Internet areas affected by the Alexandria accident
The main countries affected in Wednesday's incident

60m

12m

6m

4.7m

1.7m

0.8m

0.3m

0.2m

Capacity in terabytes per second

World cable capacity
Submarine cables operate right under the sea and can carry data across oceans, providing a vital connection to the internet.

The longest submarine cables
The longest submarine cables are the undersea cables that link different continents, carrying vast amounts of data.

The world's cables in bandwidth
The bandwidth of submarine cables can reach up to several terabytes per second, enabling rapid data transmission across oceans.

Cross-section of a cable
Cables in the ocean may be hundreds of miles long and can carry data at incredible speeds, connecting different regions of the world.
GCHQ's headquarters are in Cheltenham, Gloucestershire. There are two much smaller sites in Cornwall and Yorkshire but most of the 5500 staff work at the impressive state of the art building at Benhall in Cheltenham.
Trans-Atlantic Fibre Optic Cables
Cisco Catalyst 6500 Series Switches/Routers - Fundamental Technology for Panopticon
Evolution of All Optical Communication Network

a) Point to Point Links

b) Optical domain multiplexing

c) Photonic switching

d) Photonic computing
4 x 4 electro-optic photonic switch
MEMS Mirrors

Lucent MEMS OXC

MEMS DEVICE:
- 2-axis, angular range of $> \pm 6^\circ$
- continuous, controlled tilt
- directly scalable to 256 mirrors (1024 in the long term)
- simple technology for rapid development / prototyping
- manufacturable
Glimmerglass Intelligent Optical Switch

System 500
32x32 - 190x190
Internet Peering Exchange via Optical Switching
How much of the time are we being watched?

• Much of the time there is no observer

• In the UK it is estimated that there are 4 million surveillance cameras

• Most of the data is not looked at as we have information overload

• There is a great deal of effort going into automating the observation process via event detection
Decision-support for the person in the loop

We are addressing the problem of information overload using smart cameras to present information for:

- Decision-support
- To facilitate human intervention
- Human quality assessment
Smart IP Cameras mapped into 3D space

Alerts & Meta
Data

IP Network

Data & Meta-
Data Storage

Responders

Control Room
New Geospatial 3D Command Control Interface

Response

IP Network

Smart Camera Alerts
Smart Camera Technologies will Generate Alerts & Meta-Data

Tilera - TILEPro64 Processor

Stretch S6000 DSP

Cradle Multi DSP – CT 3616
Tilera - TILEPro64 Processor

- 8 X 8 grid of identical, RISC processor cores (tiles) optimized for both signal processing and general purpose computing
- 32-bit VLIW processors with 64-bit instruction bundle
- 5.6 Mbytes of on-chip Cache
- Up to 443 billion operations per second (BOPS)
- 37 Tbps of on-chip mesh interconnect
- Up to 50 Gbps of I/O bandwidth
- 19 – 23W @ 700MHz all cores active
Stretch S6000 DSP

- Software Configurable Processor (SCP)
  - Xtensa LX VLIW Processor
  - 2nd Generation Programmable Compute Fabric – ISEF
  - 300MHz
- Processor Array
  - Dedicated Networking and Switching Hardware
  - Glueless Processor Interconnect - AIM
- Programmable Accelerator
  - Optimized Engines for Video and Security Processing
- Technology
  - TSMC 130nm LVOD
  - 27x27 BGA, 622 Balls
  - ~ 339 Signal Pin
CT3616: 8 RISCs + 16 DSPs Loosely Coupled
- Multimedia apps, able to divide task, run parallel, multi-thread applications

Integrated RISCs
- Control/Data Flow

Smart I/O
- Eliminates I/F Chips

3-4 x Performance of Competitors
What are the Limitations of Existing Systems?

• Today’s interaction designed for point and click on individual items, groups (folders) and lists
• They assume the user knows the subject, concepts within information spaces, and can articulate what they want
• They assume data and interconnecting relationships are static in meaning over time
• They were designed 30 years ago
The New Paradigm

• We are developing robust algorithms, which will comply with i-Lids specifications, that generate metadata derived from the image processing engine.

• i-Lids scenarios
  – Sterile Zone
  – Parked Vehicle
  – Doorway Surveillance
  – Abandoned Baggage
  – Tracking

• We can provide a whole range of information from a smart camera to a control room.
- Location of event in the scene
- Time of event
- Object Velocity
- Object Size
- Object Colour
- Geo Co-ordinates
The New Paradigm

• When this information is fused into a geospatial 3D command & control interface it is possible to perform a wide range of hitherto impossible tasks such as

• tracking individuals, cars etc in “real space”.

• Map the video into 3D space and be able to instantly see the geospatial context from the live video
Integrate Data & Deploy Resources

• Using multitouch technology and a new GUI, users will be able to rapidly set up and define the areas to be analysed, be it perimeter fence, doorway, area of road etc.

• Perform rapid forensic searches against a whole range of criteria, such as blue car, moving down Cable Street between 12 and 1am on 14th August with a licence plate of ......

• To see all related video in the surrounding area at that time

• To locate and despatch rapidly the nearest resource to deal with the incident

• The system will allow wide scale collaboration on the same incident and scale data to many other screens
Imagine dozens of video/data streams from people, UAVs, and robot sensors distributed and moving through a scene…

*Problem*: visualization as separate streams/images provides no integration of information, no high-level scene comprehension, and obstructs collaboration.
Visualization as separate streams provides no integration of information, no high-level scene comprehension, and obstructs collaboration.

Many views, one 3D Picture

Courtesy of 2020 Imaging
Current Surveillance Monitoring Center

- Overwhelmed with data fusion and comprehension of multiple image streams.
- Limited number of displays
- Waste of Resources

Better Surveillance System

- Better understanding of video streams
- Better use of resources
- Additional capabilities: tracking, statistics

The Old v The New
Augmented Video Environment

- **VE**: captures only a snapshot of the real world, therefore lacks any representation of dynamic events and activities occurring in the scene

- **AVE Approach**: uses sensor models and 3D models of the scene to integrate dynamic video/image data from different sources

- Visualize all data in a single context to maximize collaboration and comprehension of the big-picture

- Address dynamic visualization and change detection
Tracking using live Video and 3D

- Tracking in 2D and modeling in pseudo 3D
Cameras Mapped into 3D Geo Space
## Biometric Performance

<table>
<thead>
<tr>
<th>Biometrics</th>
<th>Universality</th>
<th>Uniqueness</th>
<th>Permanence</th>
<th>Collectability</th>
<th>Performance</th>
<th>Acceptability</th>
<th>Circumvention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Fingerprint</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Hand Geometry</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Keystroke Dynamics</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Hand vein</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Iris</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Retina</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Signature</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Voice</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>Facial Thermogram</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>DNA</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

H=High, M=Medium, L=Low
Mobile Iris Biometric ID System

Locate Iris Image → Acquire Iris Image → Transmit Iris Data → Convert Iris Data → Store Iris Data → Microchip → Datamatrix → Local Database → Remote Database

Acquire & Convert Iris Biometric into Data
Mobile Iris Biometric ID System

(a) Phone Screen Display

(b) Iris Captured for processing

(a) Screen display of successful Iris capture & processing less than 1 second.

(b) Captured image for processing with grid overlay
Scan to Compare Iris Biometric with Remote & Local Database (Iris/Microchip/Datamatrix)
Vein pattern recognition hardware

14 Infrared LEDs with 810nm wavelength
USB powered (5V-500mA max)

Finger placed on its dorsal side

CMOS webcam
Infrared (plastic) filter to cut-off visible light
Vein pattern image enhancement

Image without using the infrared pass filter

Image after using the pass filter
RFID
Untethered Trailer Tracking Wireless Terrestrial Communications
Track & Trace

Real-Time Updating from any Location

Worldwide authentication & tracking

Standard Labelling Carries Unique Identifier

In-Field Authentication
Conclusion

At the moment the observer doesn’t have the resources to watch for very long.

It is clear from current research activity in Industry and Universities that the amount of time the observer is actually watching is going to increase.

It’s a new business sector so it is likely to expand.
1. RKK Wang, L Shang, CR Chatwin, “Modified fringe-adjusted joint transform correlation to accommodate noise in the input scene,” Applied optics 35 (2), 286-296, 1996
15. RK Wang, CR Chatwin, RCD Young, Assessment of a Wiener filter synthetic discriminant function for optical correlation, Optics and lasers in engineering 22 (1), 33-51, 1995
27. II Kypraios, R Young, P Birch, C Chatwin, “Object recognition within cluttered scenes employing a hybrid optical neural network filter,” Optical Engineering 43 (8), 1839-1850, 2004
29. PM Birch, RCD Young, F Claret-Tournier, CR Chatwin, “Automated vehicle occupancy monitoring,” Optical Engineering 43 (8), 1828-1832, 2004