Centre for
Data Analytics

Insight

The Sensor Web

New Opportunities for Media-Mixing

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7th Jan 2014

DCU NUI Galway Ollscoil na Gaillimh UCC UCD SFI

Outline

The Sensor Web

What it is, what's driving it and the challenges posed

New challenges / opportunities in data analysis

"Big data" is not just a buzz word …

Multi-modal analysis, leveraging complementary data sources

Key challenge

Identifying useful media fragments from the new data sources available

Case studies

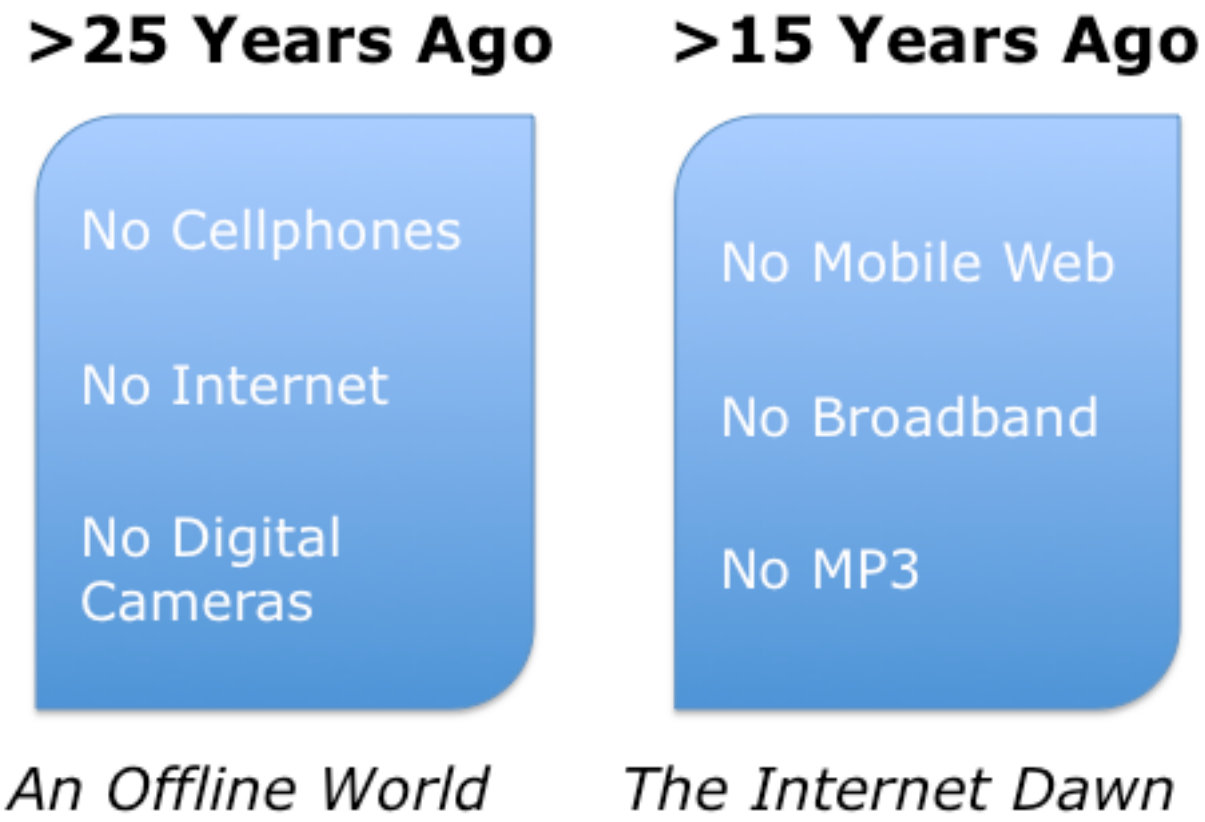
Sports event analysis and understanding for next generation media applications

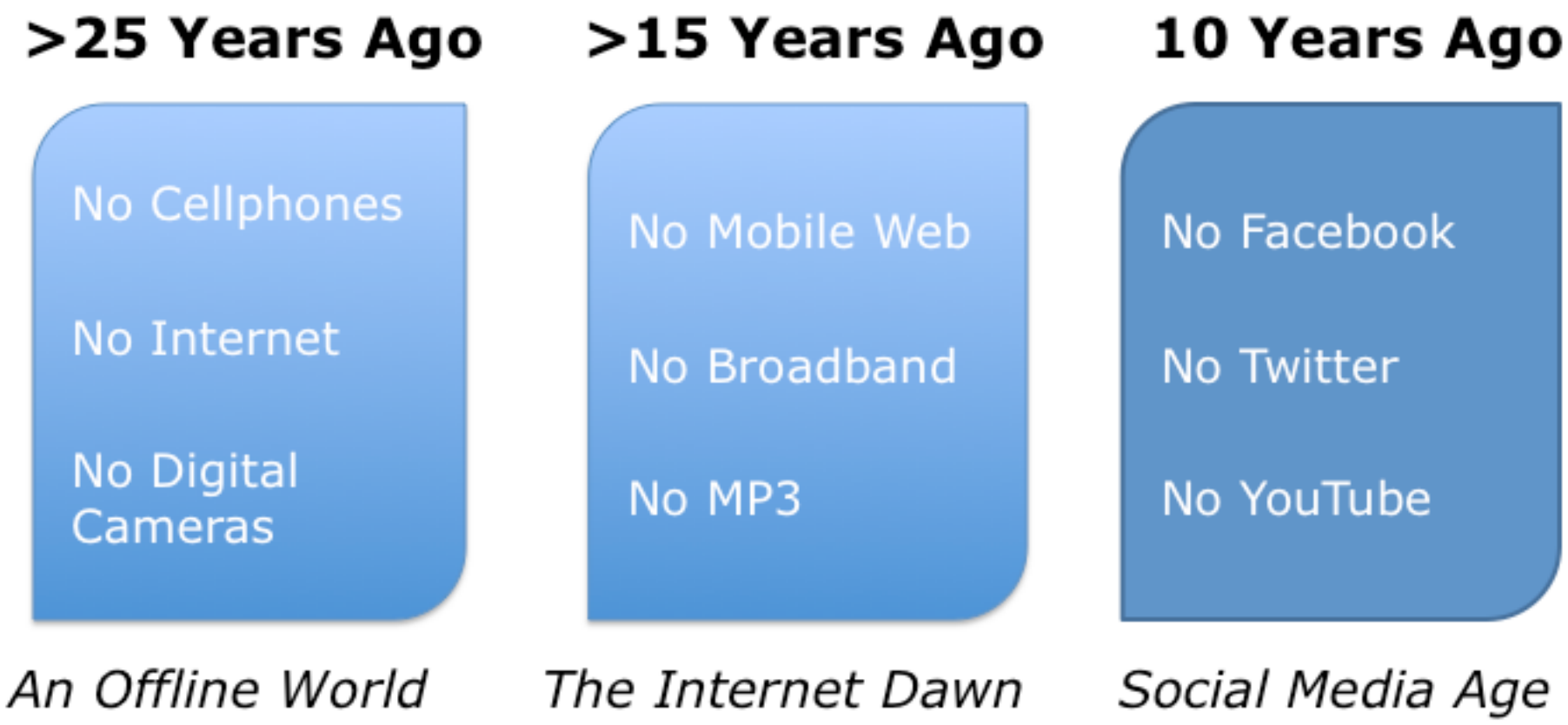
How far have we come?

(and where are we going?)

>25 Years Ago

An Offline World

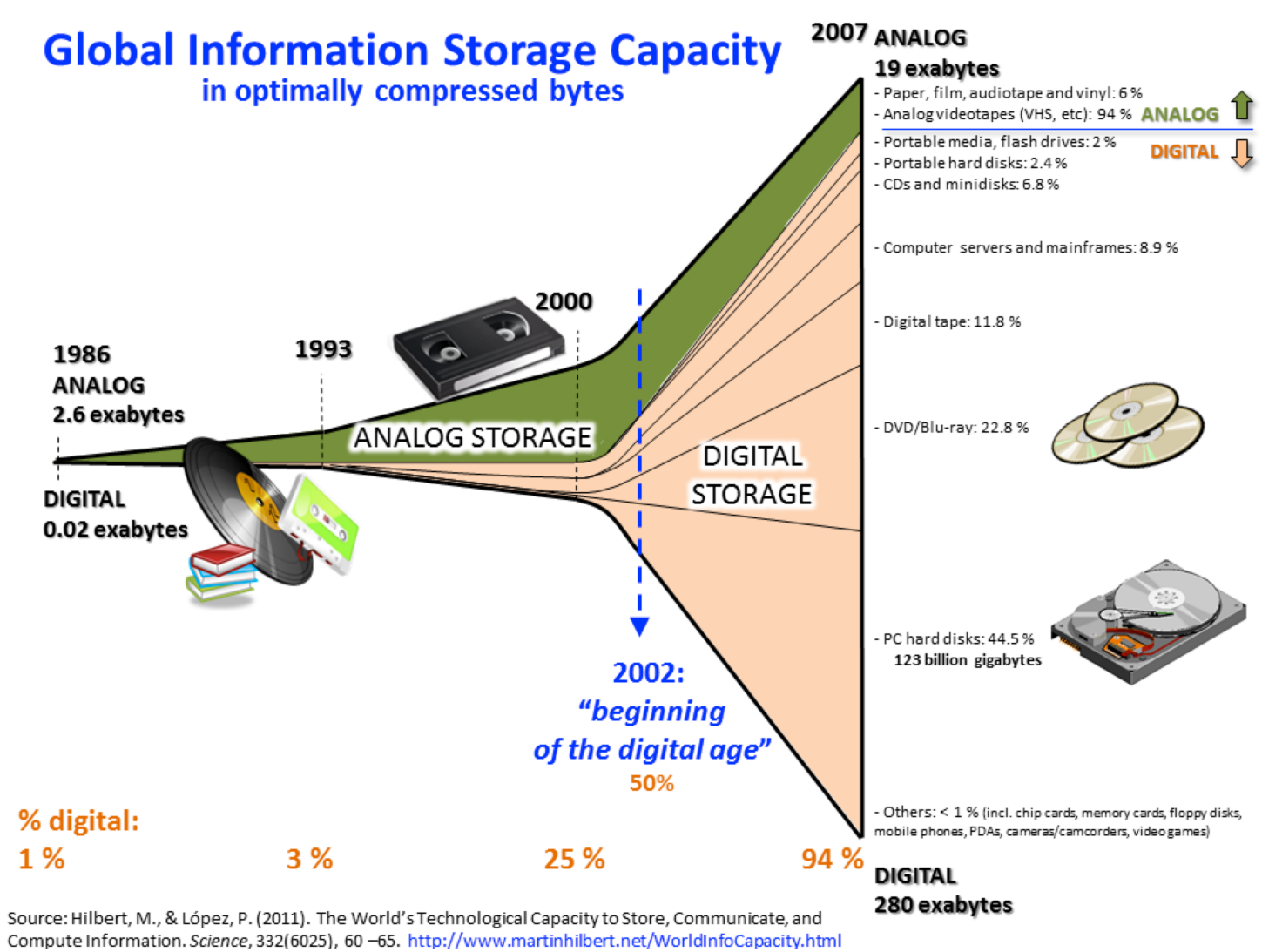

>25 Years Ago
No Cellphones
No Internet
No Digital Cameras
An Offline World
>15 Years Ago
No Mobile Web
No Broadband
No MP3
The Internet Dawn


>25 Years Ago
No Cellphones
No Internet
No Digital Cameras
An Offline World
>15 Years Ago
No Mobile Web
No Broadband
No MP3
The Internet Dawn
10 Years Ago
No Facebook
No Twitter
No YouTube
Social Media Age

Result?

More and more data

In 2007 … 280 exabytes … 1.2B HDD



Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html

That was 2007 …

Gigabytes, terabytes, petabytes, exabytes

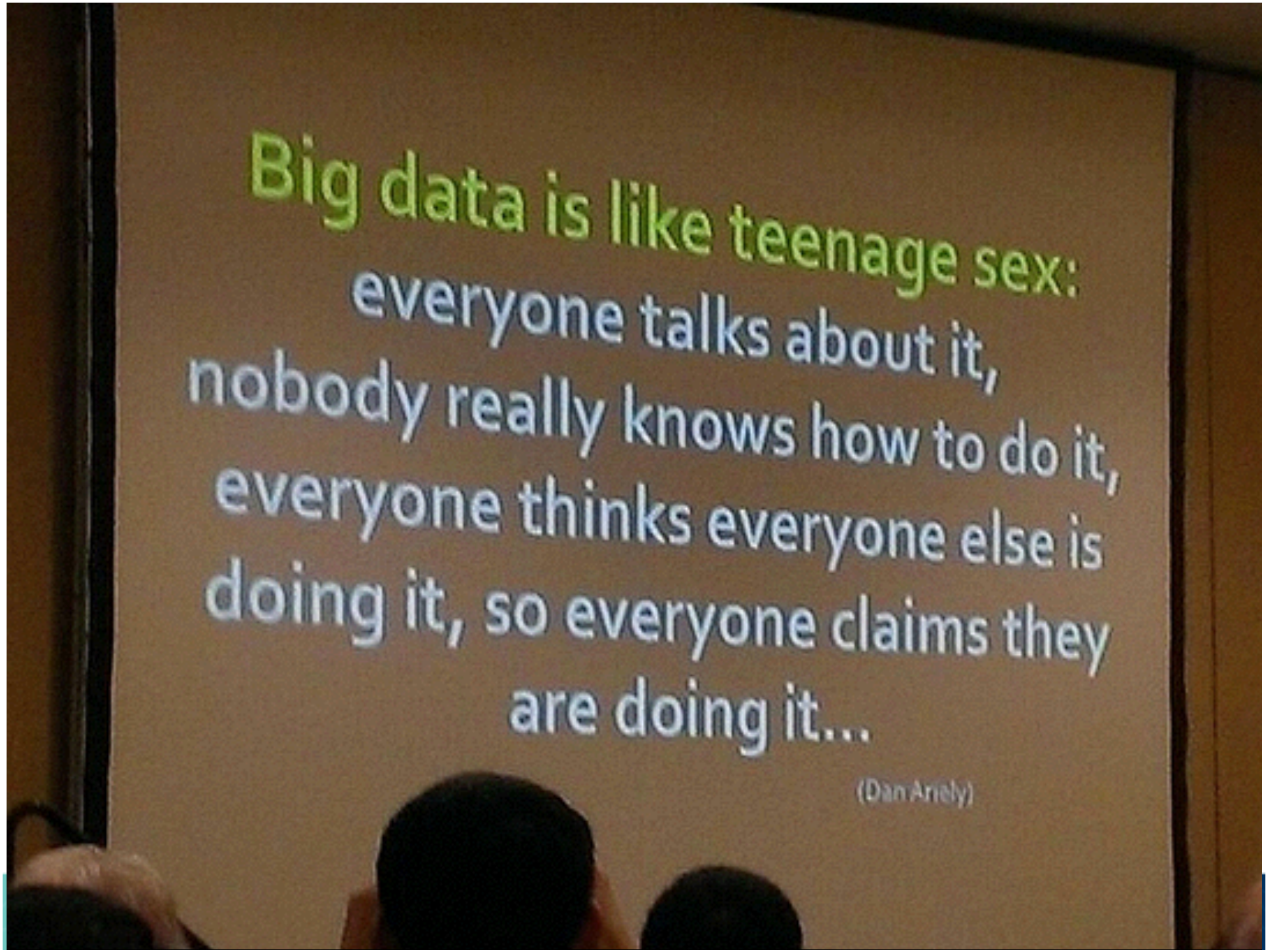
Since then :

genetic analysis for $100, EEGs for $150, Nike+ fuelband,
… biology and physiology is now a data science

digital broadcasting, new online (social) media

astronomy generates more than can be stored

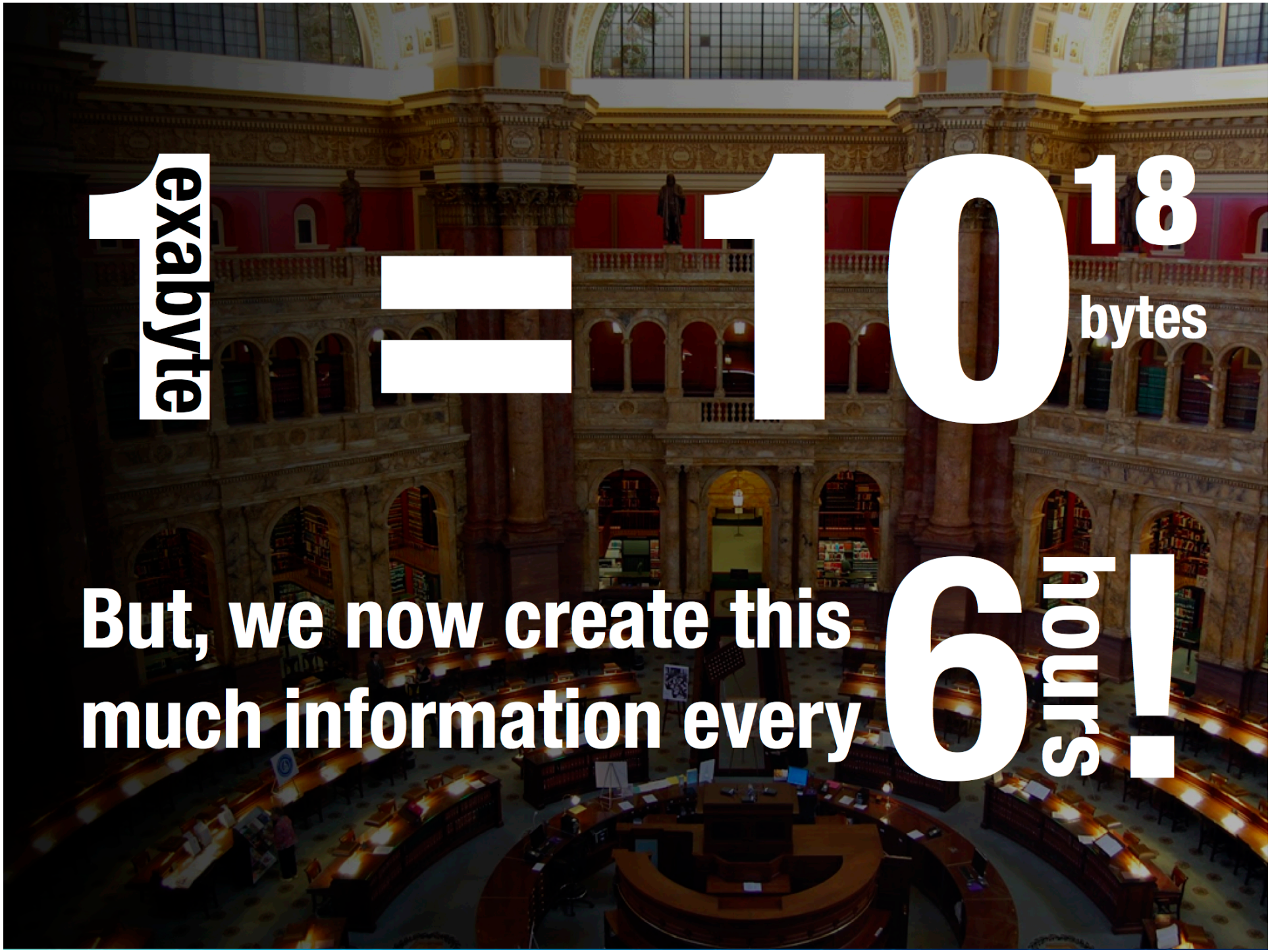
Big Data!


Big data is like teenage sex:
everyone talks about it,
nobody really knows how to do it,
everyone thinks everyone else is
doing it, so everyone claims they
are doing it...
(Dan Ariely)

SO HOW BIG IS BIG DATA?

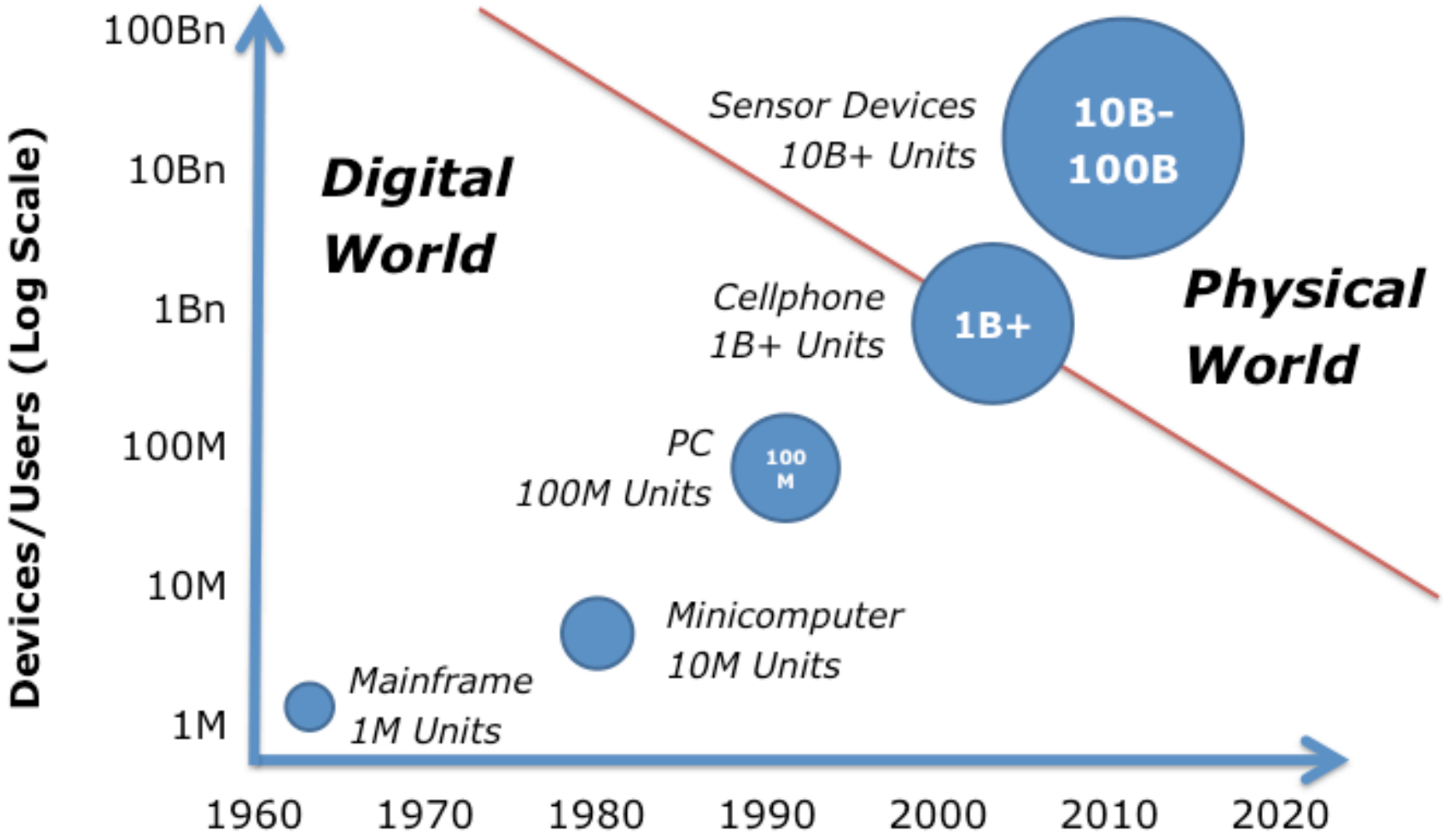

1 exabyte
= 10^18 bytes
1000,000,000,000,000,000


1 exabyte = 10^{18} bytes
20,000 x all of the printed material in the
US Library of Congress.
Or all of the words spoken by humans. Ever!


1 exabyte = 10^{18} bytes
But, we now create this much information every 6 hours!

What's driving this?

Digital data created in the physical world


Devices/Users (Log Scale)
100Bn
10Bn
1Bn
100M
10M
1M
1960
1970
1980
1990
2000
2010
2020
Digital World
Physical World
Sensor Devices
10B+ Units
10B-100B
Cellphone
1B+ Units
1B+
PC
100M Units
100 M
Minicomputer
10M Units
Mainframe
1M Units

1 Trillion
Connected Devices

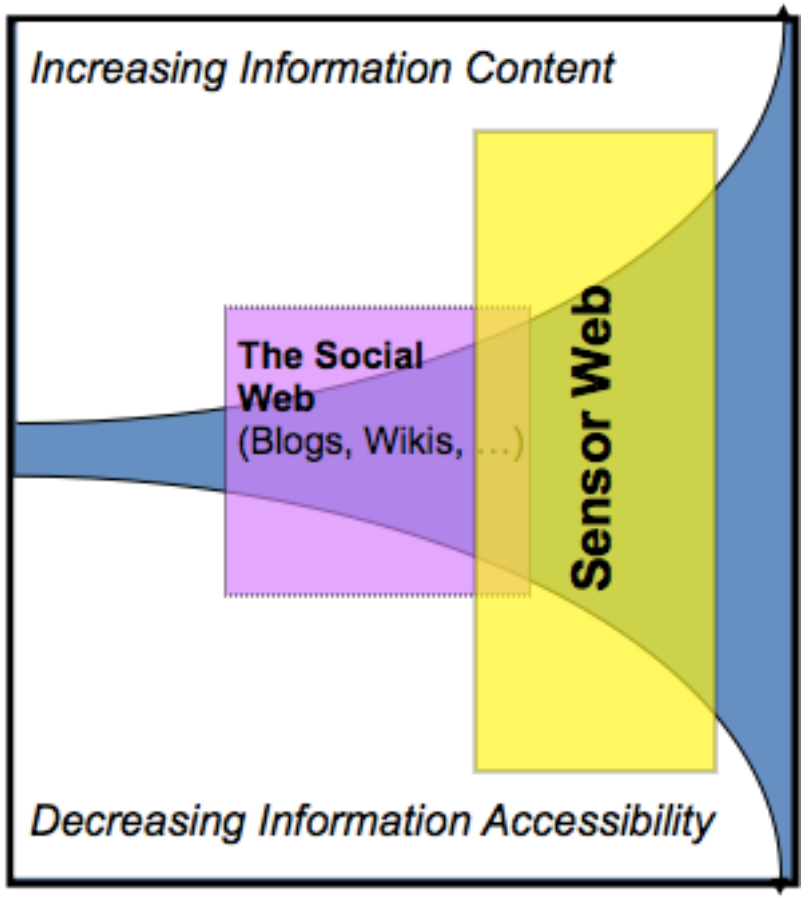
2011 - 2015

Information Access Problem

The Social Web

Conventional information access tools are failing to cope with new forms of online information and content

Dynamic user generated content (UGC) on the 'Social Web'



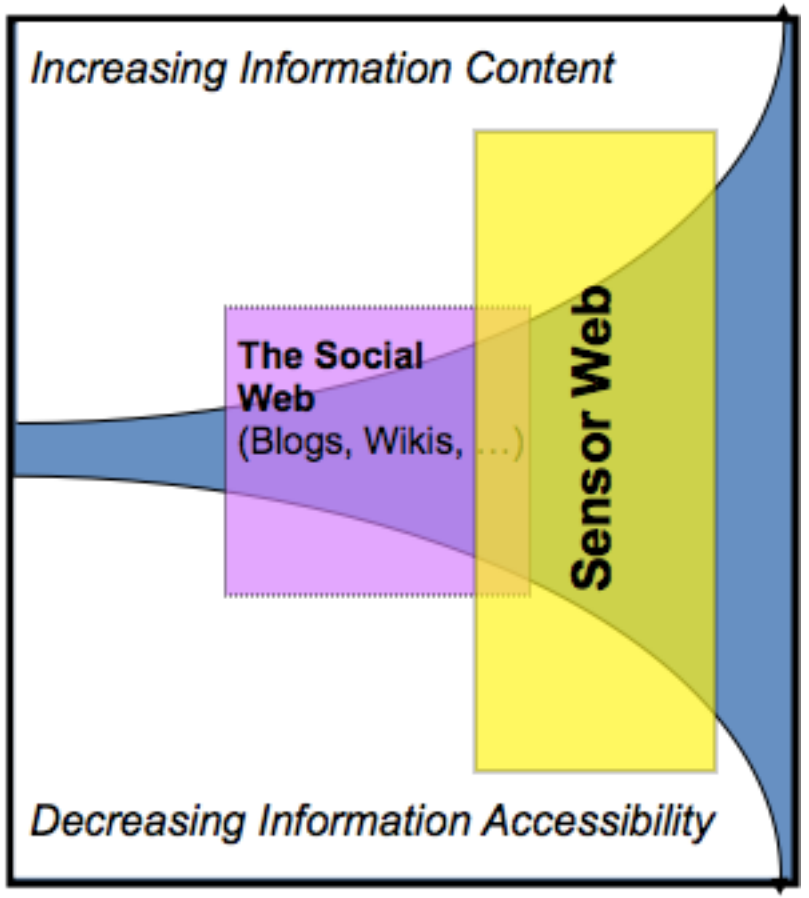
Information Access Problem

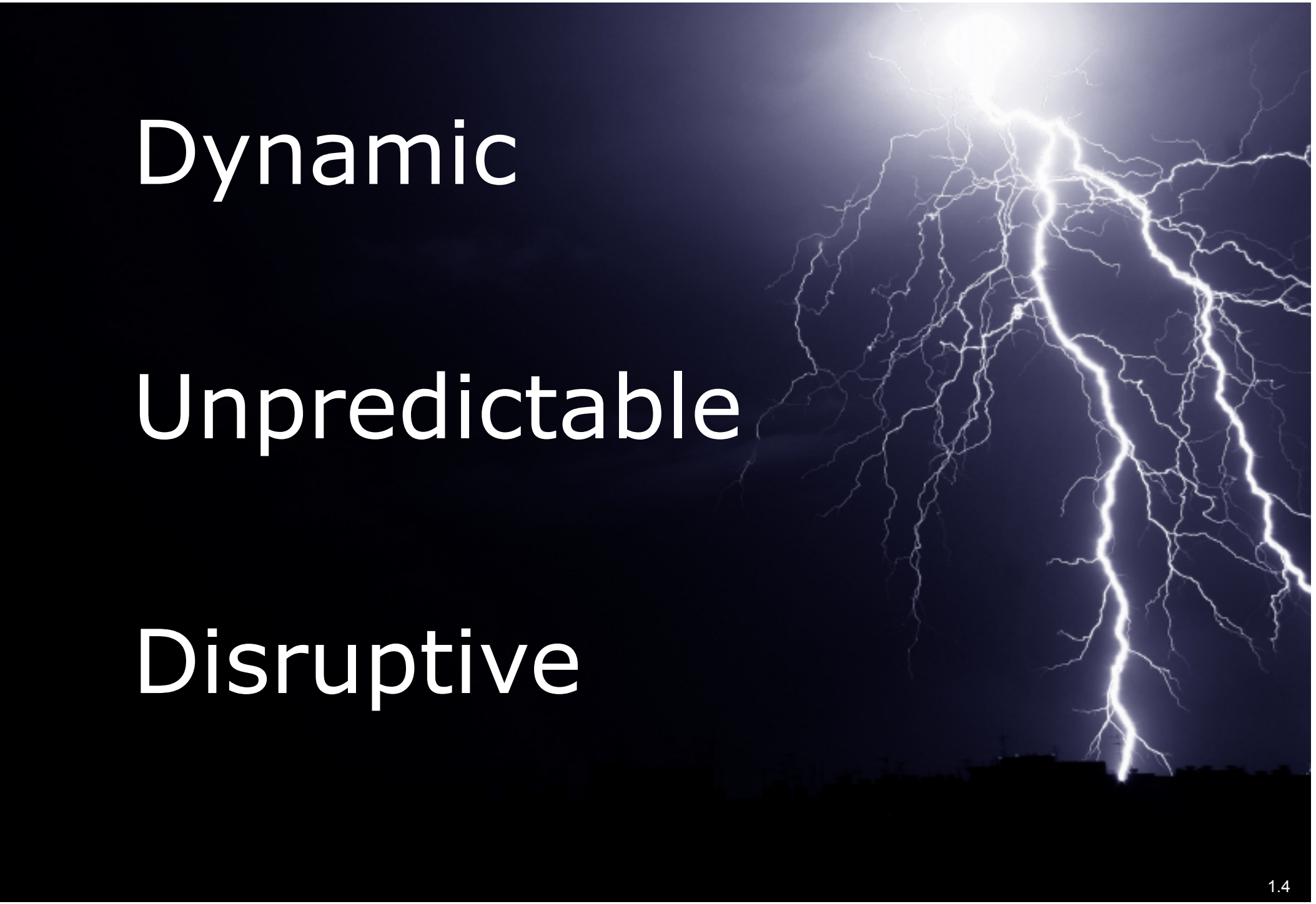
The Sensor Web

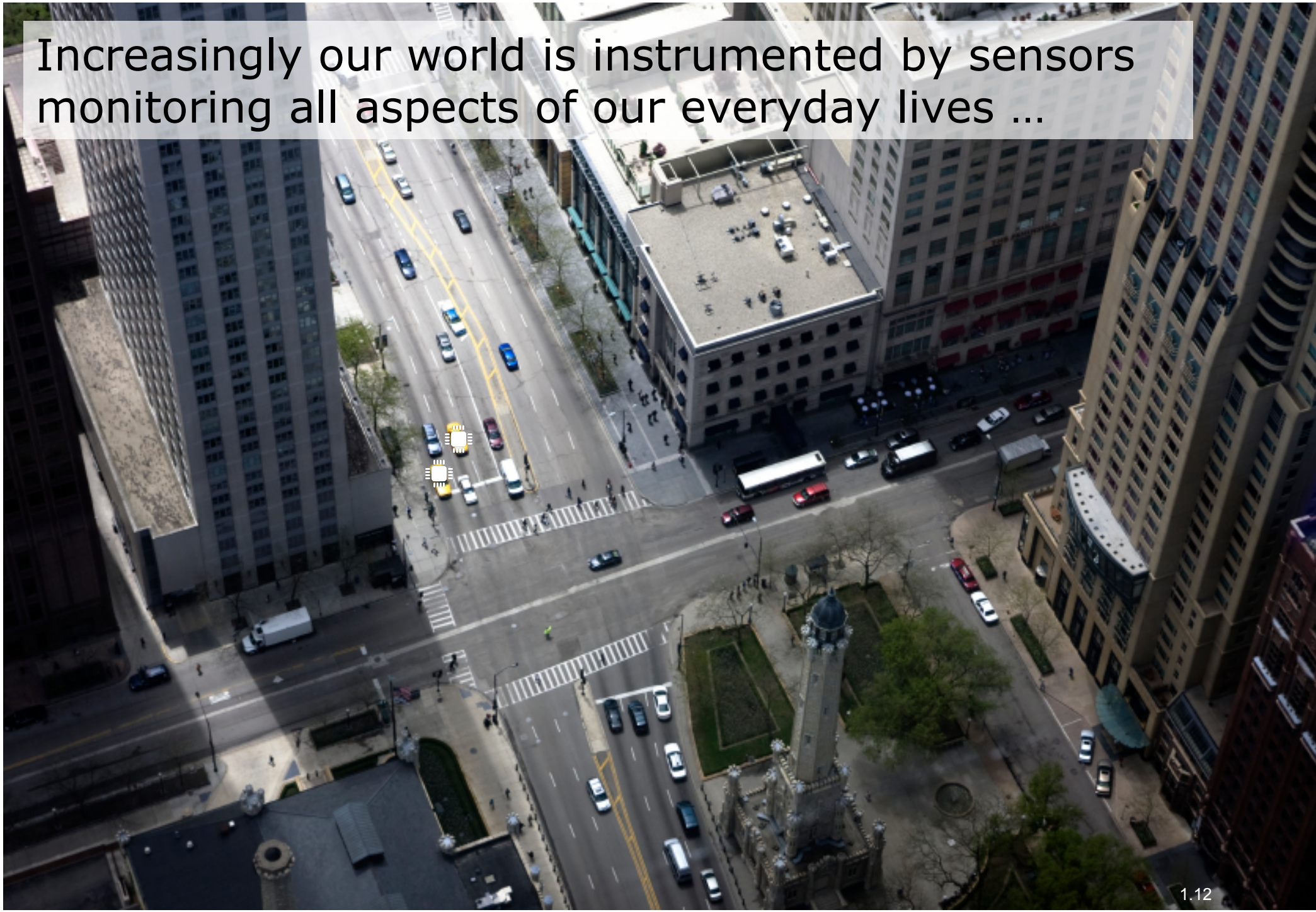
The increasing availability of cheap, robust, and deployable sensor technologies

A new wave of ubiquitous information sources

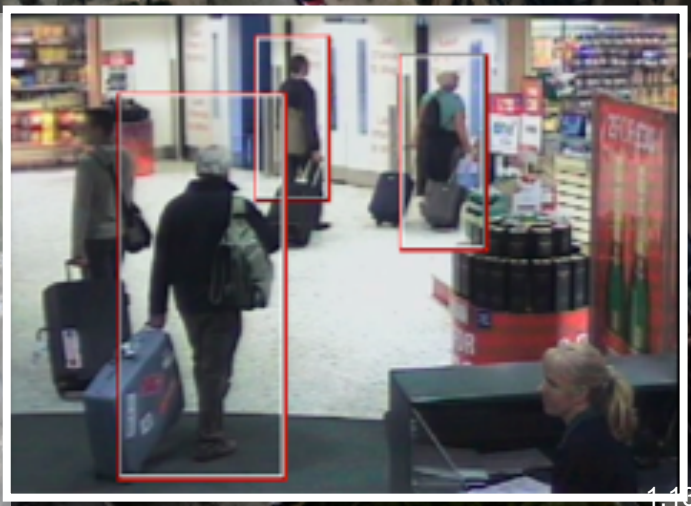
Dynamic, noisy, reactive, unstructured data-streams




Dynamic
Unpredictable
Disruptive

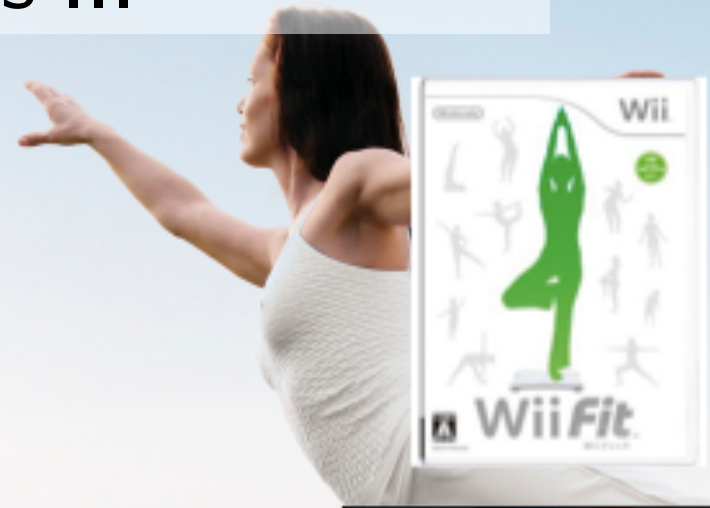

Increasingly our world is instrumented by sensors monitoring all aspects of our everyday lives …

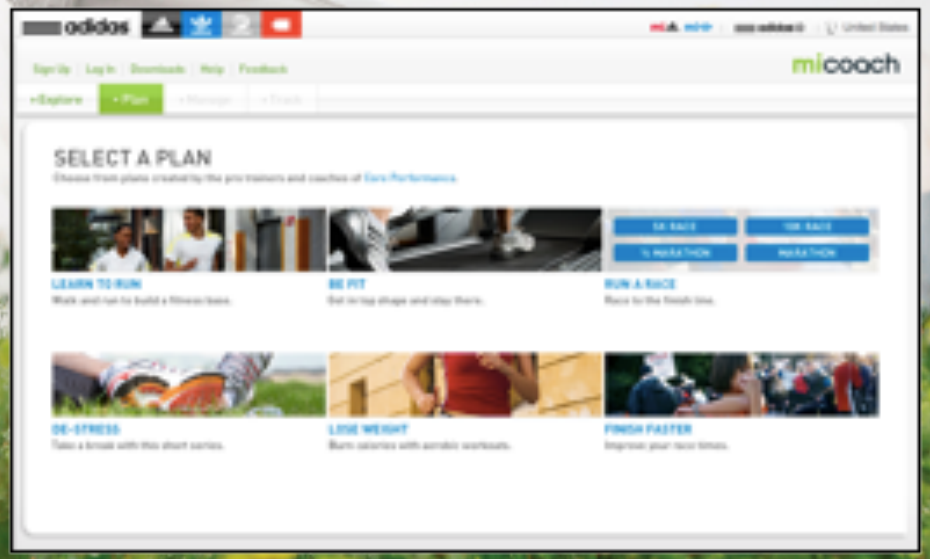
... CCTV is a hugely deployed visual sensor network ... that is useless except in a forensic capacity ...

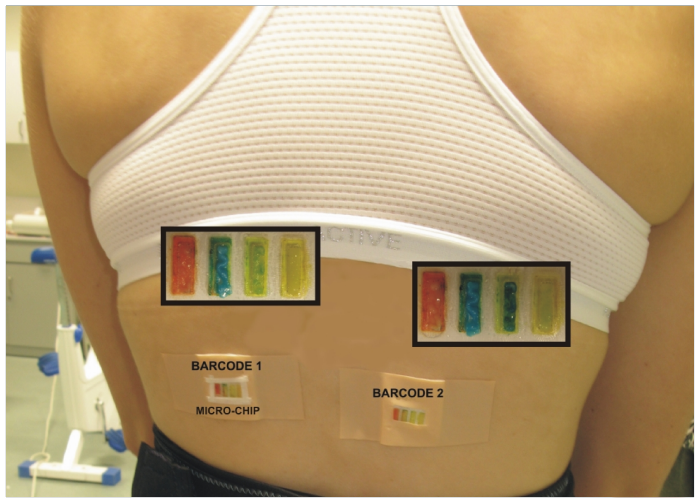


Early sensor web applications are already changing how we exercise and train (eg Nike+, Nintendo Wi, MS Kinect)

… simple, robust sensors of physical activity, leading to active online communities ...







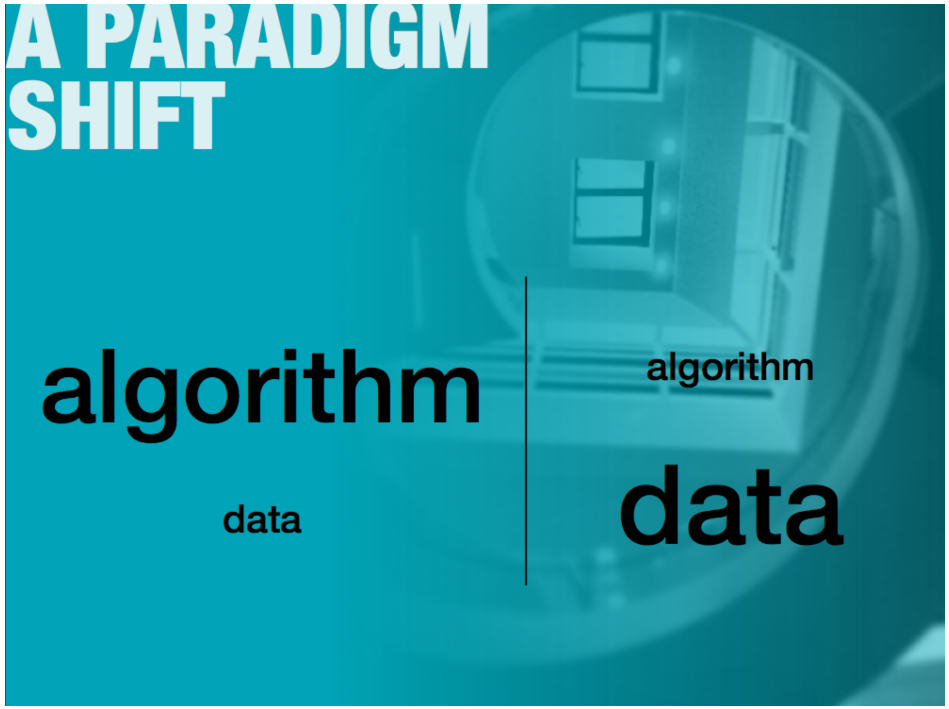
"wearable barcodes" based on washable microfluidics to determine sweat pH. Cost-effective, fast-acting, reliable, and flexible.

Instrumented sports facilities … CCTV … not for security but feedback … wearable sensors for individual performance monitoring

Improved, real-time water monitoring/ management, water quality assessment, …

Moving from the “guy in a van” to autonomous long-term water quality sensing units … “Deploy and Forget” … real-time continuous updates

What do we do with it?



Storage

Our capacity to store information
has roughly doubled every 40 months
since the 1980s

But storing isn't enough

Media Analytics

Process, analyse, understand, visualise
Software running on thousands of servers
Processes to learn from data, and to mine patterns

To summarise

(before we all fall asleep)

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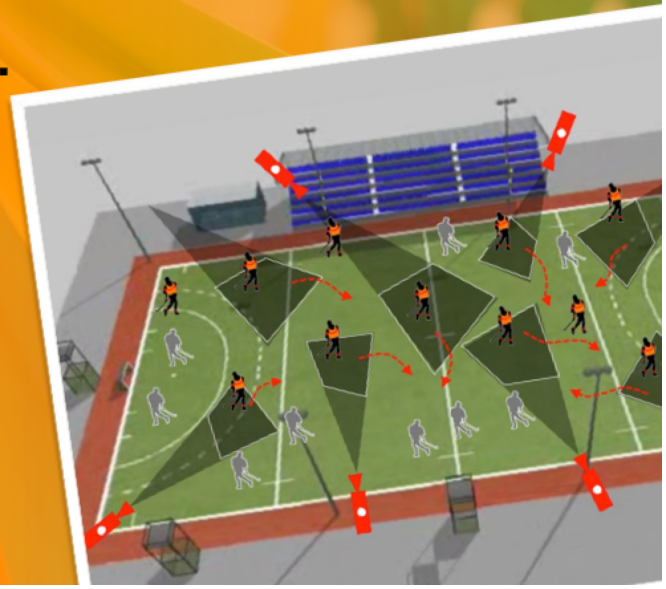
Big data is really here

CAPTURING REAL-WORLD DATA

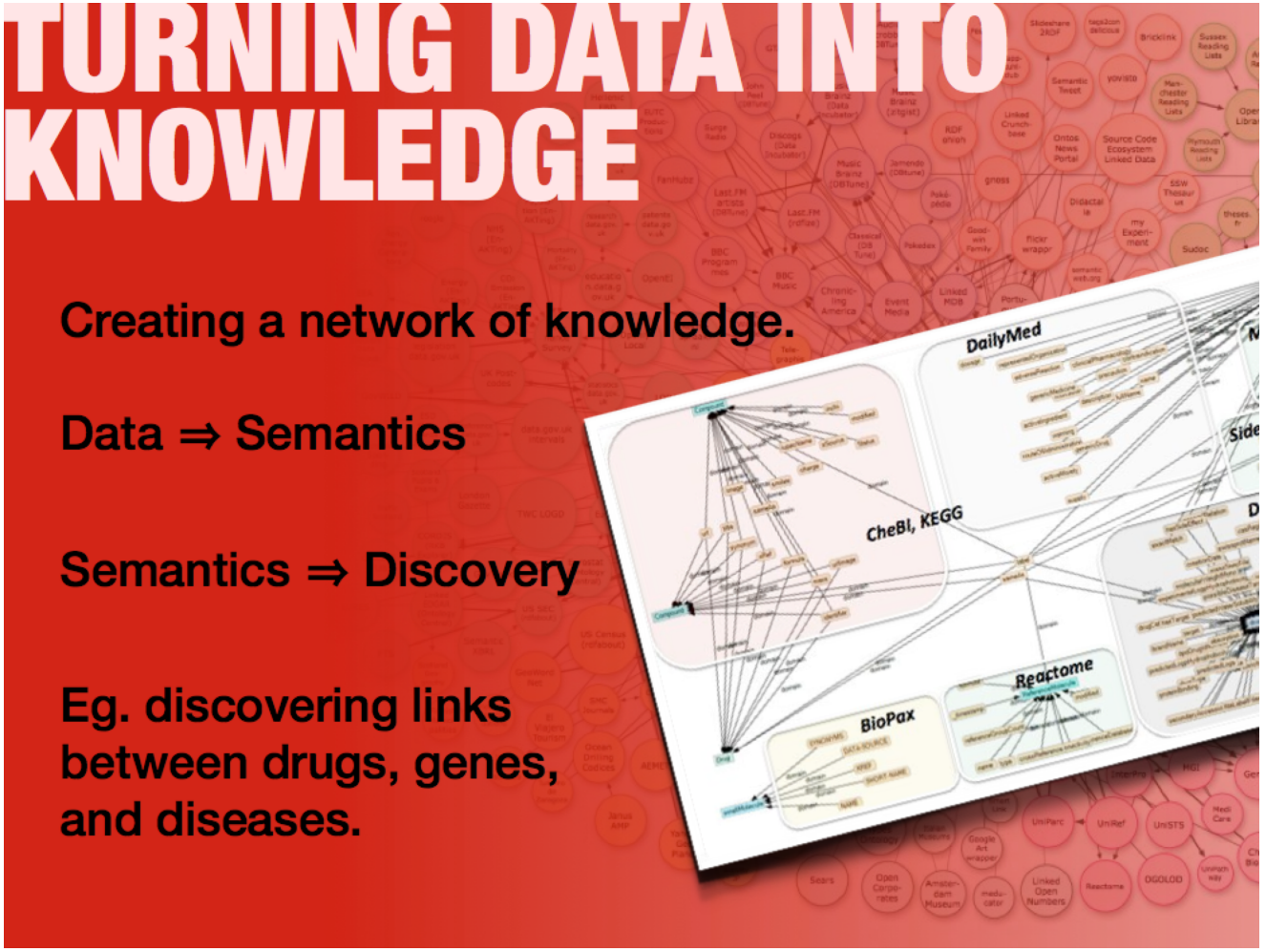
Online vs real-world sensing …

Multi-modal, real-time, …

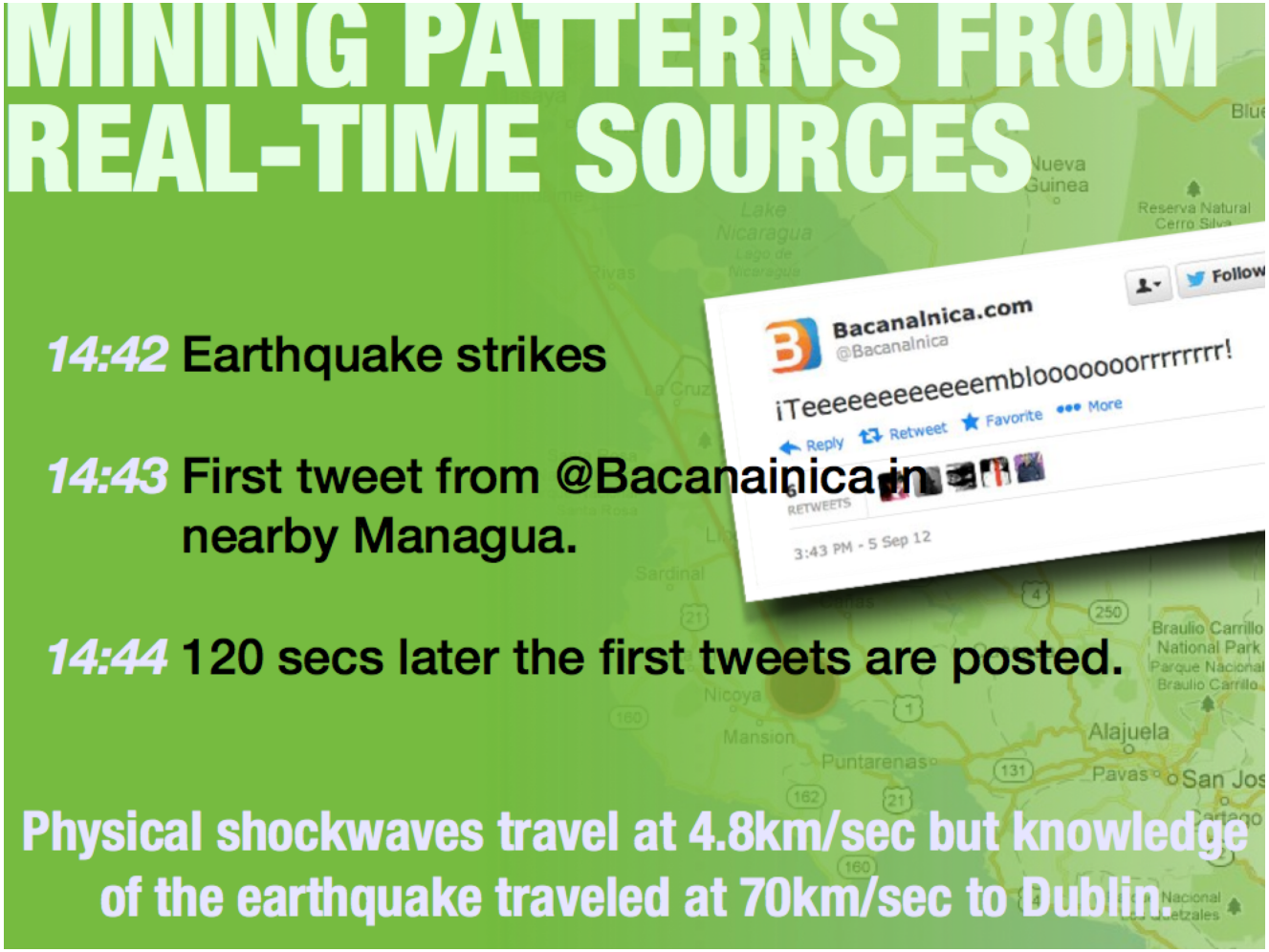
Lifestyle, clinical,
sporting, media, retail …



The end-game


TURNING DATA INTO KNOWLEDGE
Creating a network of knowledge.
Data ⇒ Semantics
Semantics ⇒ Discovery
Eg. discovering links between drugs, genes, and diseases.
DailyMed
CheBI, KEGG
Reactome
BioPax

How do we do this ?



What does ANY of this have to do with media mixing?

(this question ruined my Xmas!)

(Thanks a lot Benoit and Vassilis)

I did some homework

Better start by learning what's meant by media mixing

Luckily there's a very useful guide online

Web site and community portal: http://mediamixer.eu/

Deliverable 1.1.2: Report on MediaMixer core technology set

Section 3: Media Fragment Creation

Shot segmentation, concept detection, object redetection

Analysing digital content (video) to find and understand media fragments

Section 7: Media Fragment Lifecycle

Fragment provision to 3rd parties, linking to other media, personalised services, …

Let’s take a case study

Sports event detection

Equally relevant to archive/broadcast scenarios and “new” Sensor Web opportunities

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Sports event analysis

Automatic event detection and classif

Annotations that can be used to i

Browsi

D

Se

Allow users to filter on certain specific events

Summarization

The most exciting parts of a 90min soccer match on your smart phone, tablet or set-top box

Media Fragments!

Soccer

Rugby

Hockey

Gaelic Football

Hurling

Common characteristics

Field end zone activity

Score board activity

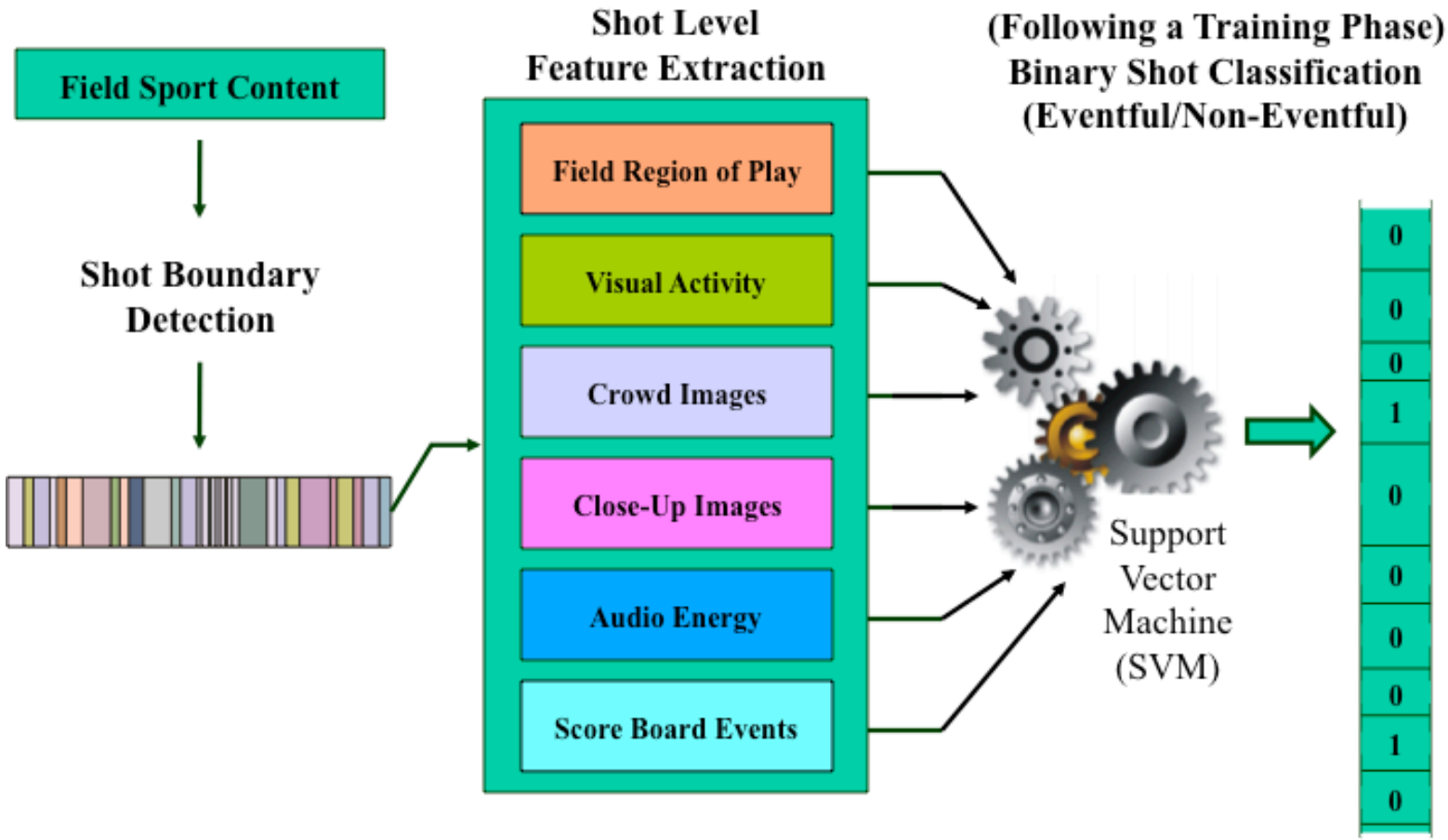
Increased audio activity

Increased near field visual activity

Cut to crowd image

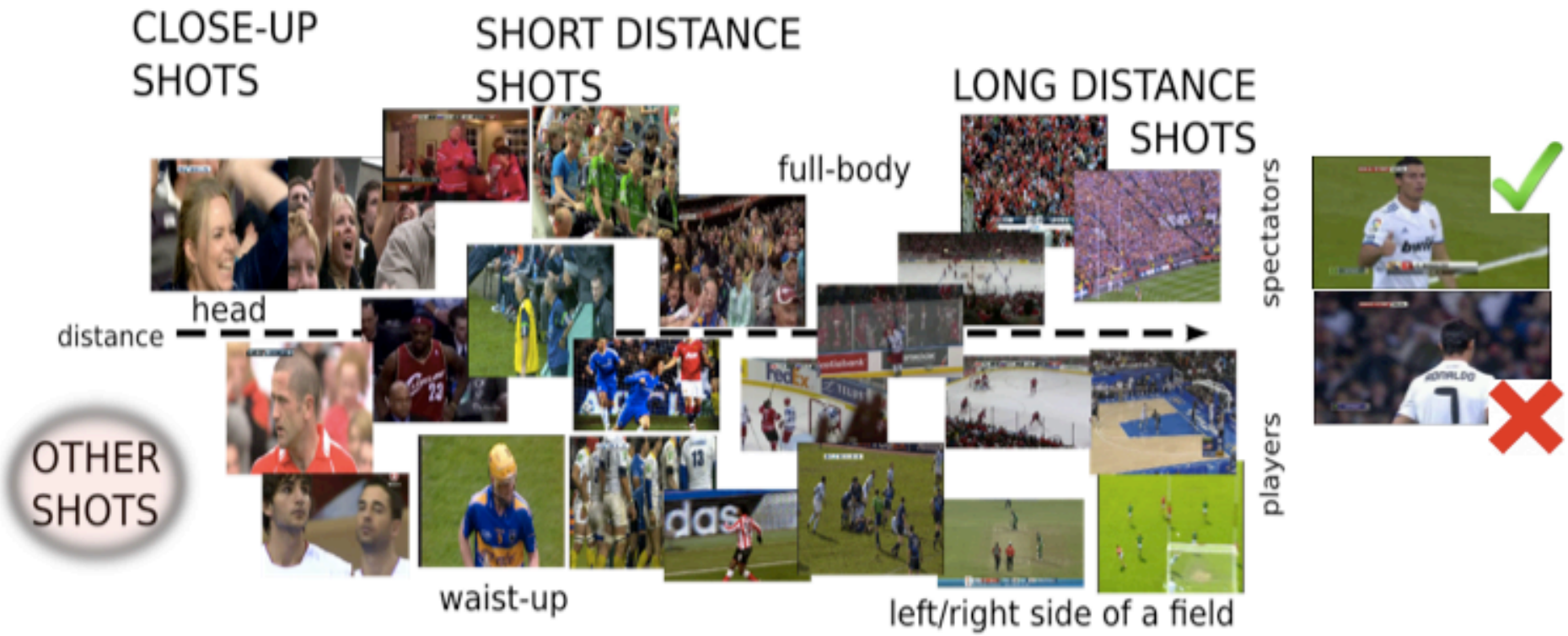
Cut to close up image

Traditional approach



Sadlier & O'Connor, IEEE Trans. CSVT 15(10): 1225-1233 (2005)

Something a bit more recent



See also: Liang Bai et al, Comput. J. 52(7): 808-823 (2009)

Something a bit more recent

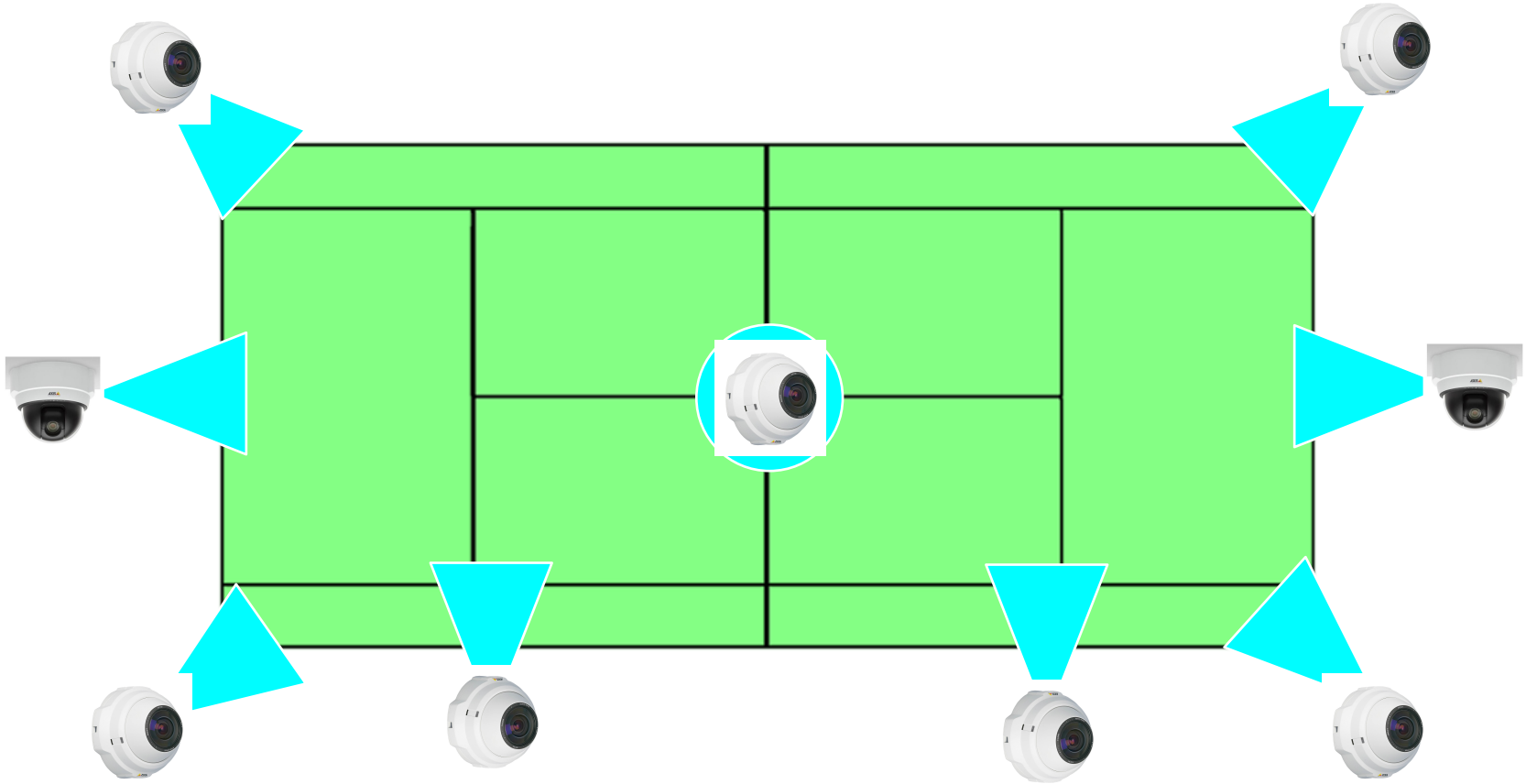

RTÉ 43:25 DUB 0-11 0-09 MTH
LS
LR
LL
LC
SPC
SPS
SP
SS
CLWUC
CLWUS
CLWU
CLHC
CLHS
CLH

Something a bit more recent

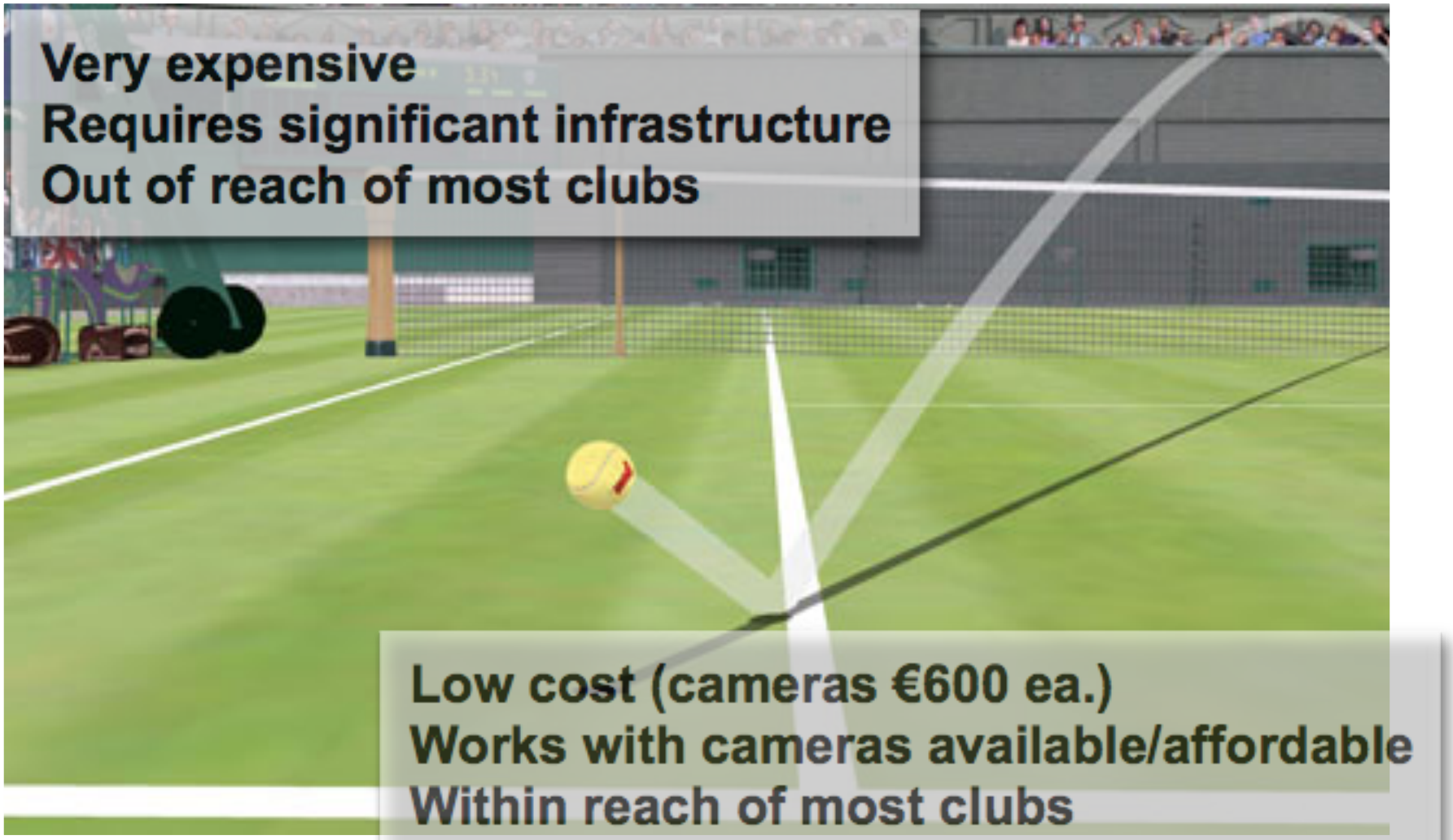
What if stadiums & players were instrumented?

Not just big stadia
or
professional athletes either!

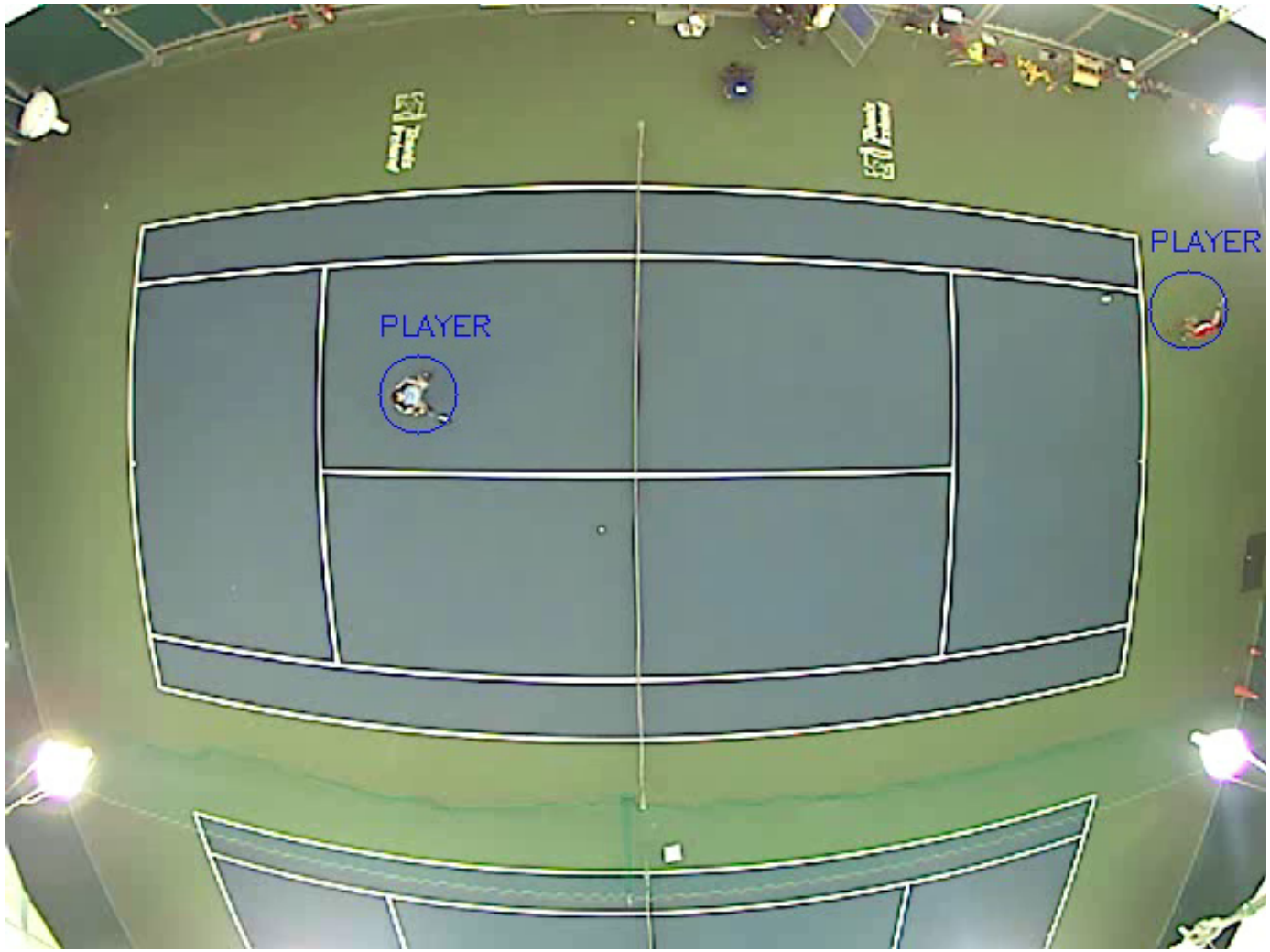
Installation at national tennis facilities



Not Hawkeye!


Very expensive
Requires significant infrastructure
Out of reach of most clubs
Low cost (cameras €600 ea.)
Works with cameras available/affordable
Within reach of most clubs

Ball/player Tracking

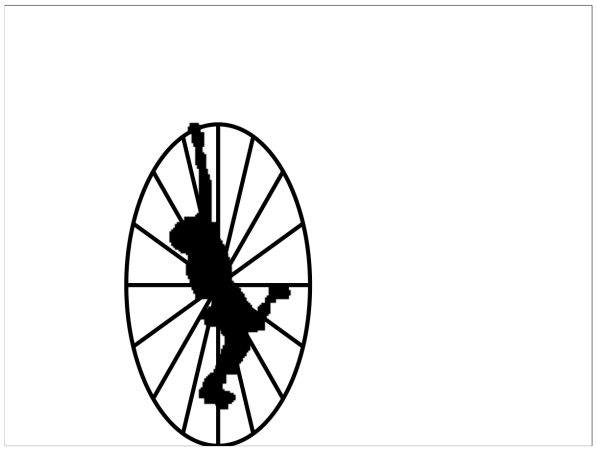


Stroke Recognition

Automatically tag serves, forehands, backhands

Works with single baseline camera

98% accuracy for elite athletes
With optional single accelerator on forearm



Stroke Recognition

Connaghan & O'Connor, ACM Multimedia 2012: 1089-1092

Match Point

Automatic recording and ind
Reduce the time a coach t
Retrieve a specific
court

Media Fragments!

events for later playback
A match played according to ITF rules

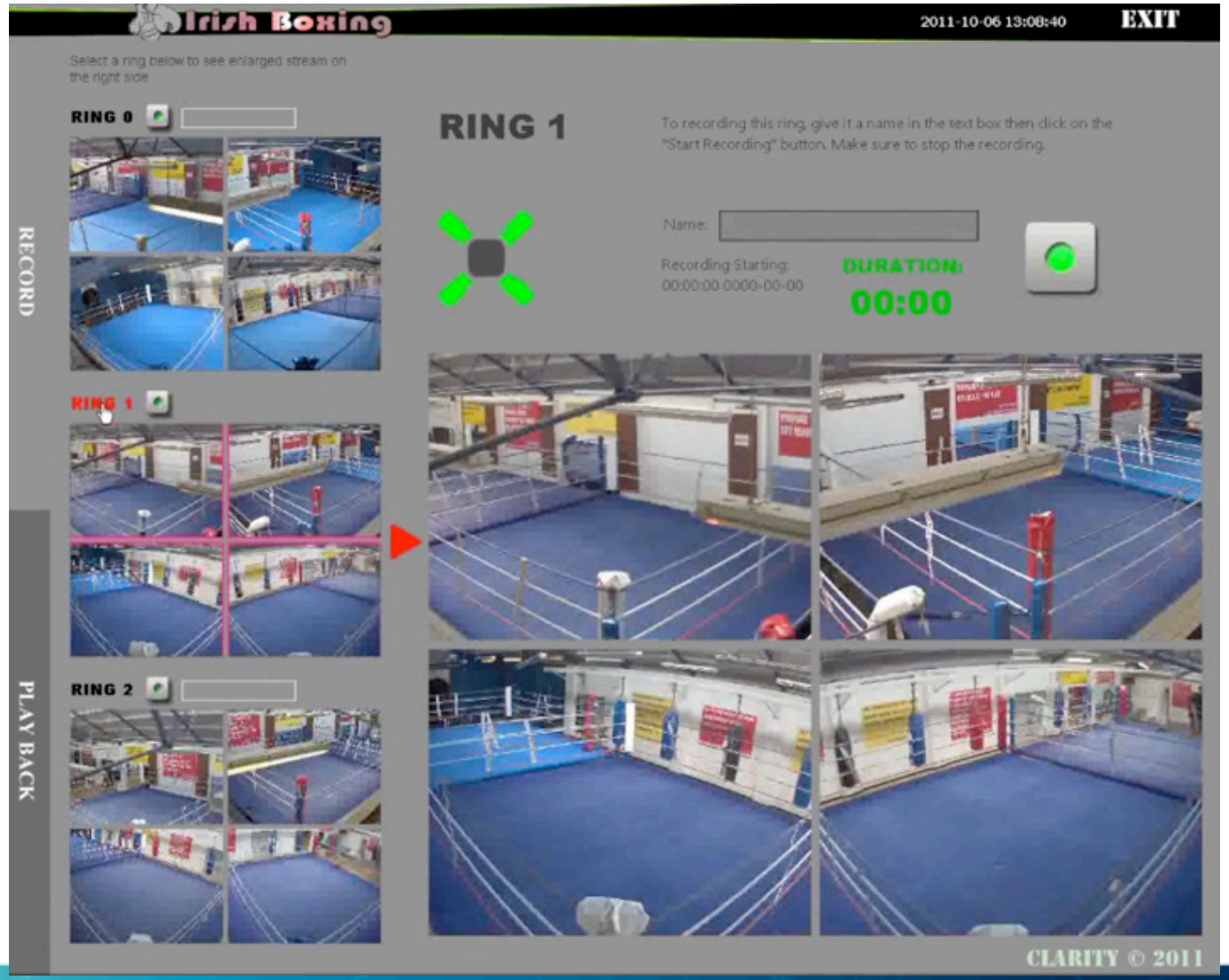
Supports automatic tagging of
Stroke played: serve, forehand, backhand
Start/end of game & set

Connaghan et al, Proc IMechE Part P: J Sports Eng. & Tech. 227(4) 273–288

Match Point


Alexander
Carlos
Tim
Adam
Edmond
Dave
Jogile
Tony
Ian
Damien
Chris
Damien C
Peng
Piotr
Bart
1 2 –
Search
Serves
Forehands
Backhands
Serves
T (7)
Body (23)
Wide (39)
Net (11)
All (138)
Forehands
In to In (59)
In to Out (10)
Line (52)
Cross (77)
All (211)
Backhands
In to In (59)
In to Out (12)
Line (10)
Cross (14)
All (108)
Rallies
Size: 6
Ending with:
any stroke
Find...
60 MINUTES
3324/6707 14/04/2011 Tony v Damien

People want this!



New media: Motion capture

Optical MoCap

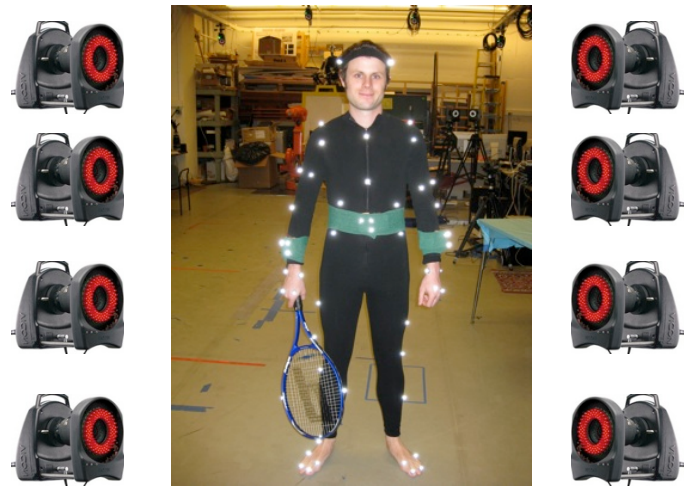
Cumbersome, expensive
Motion confined to small area
Markers interfere with movement

Our approach

Cheap, accurate and unobtrusive

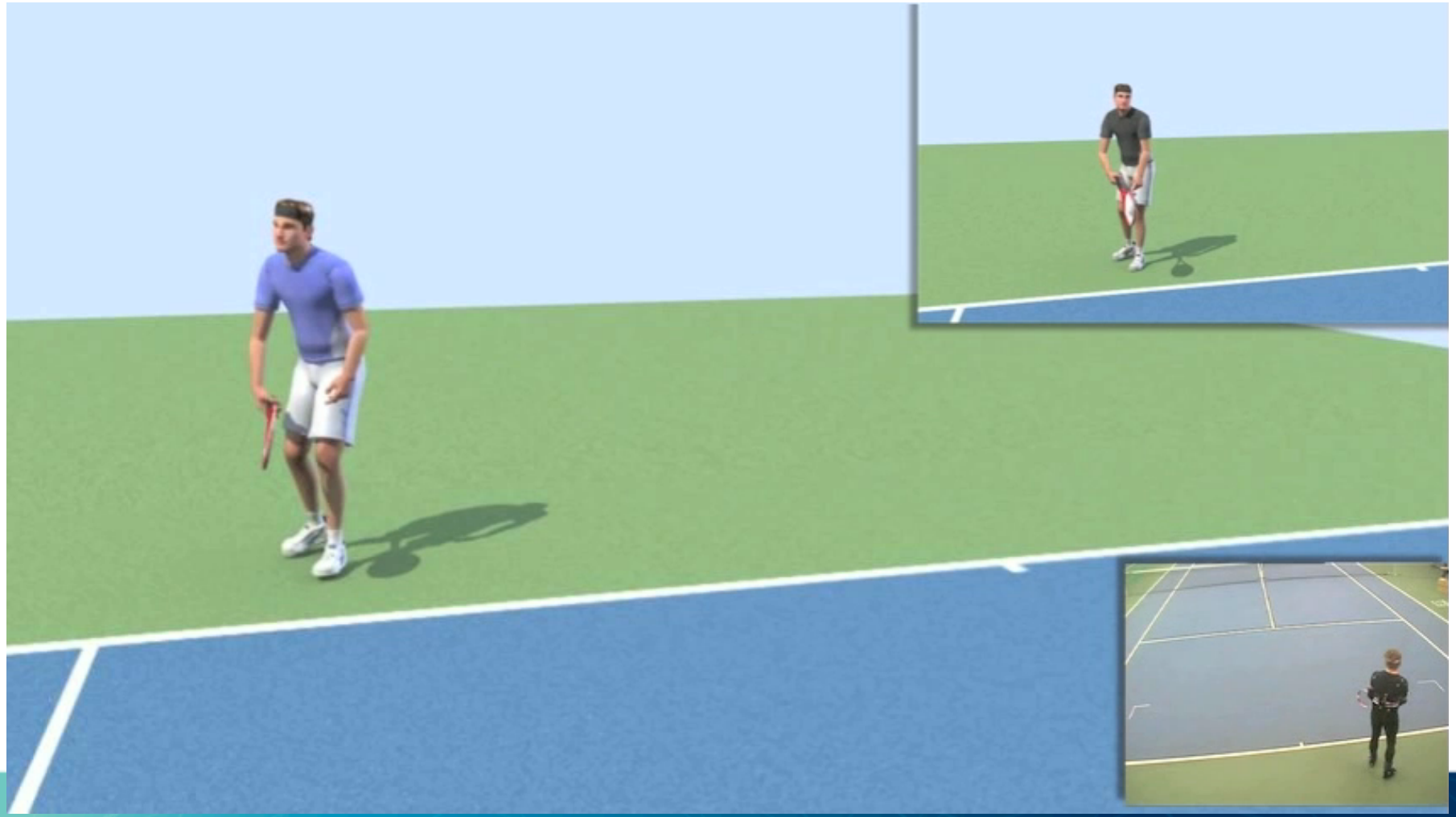
Small no. of WIMUs

Wrists, shins, chest



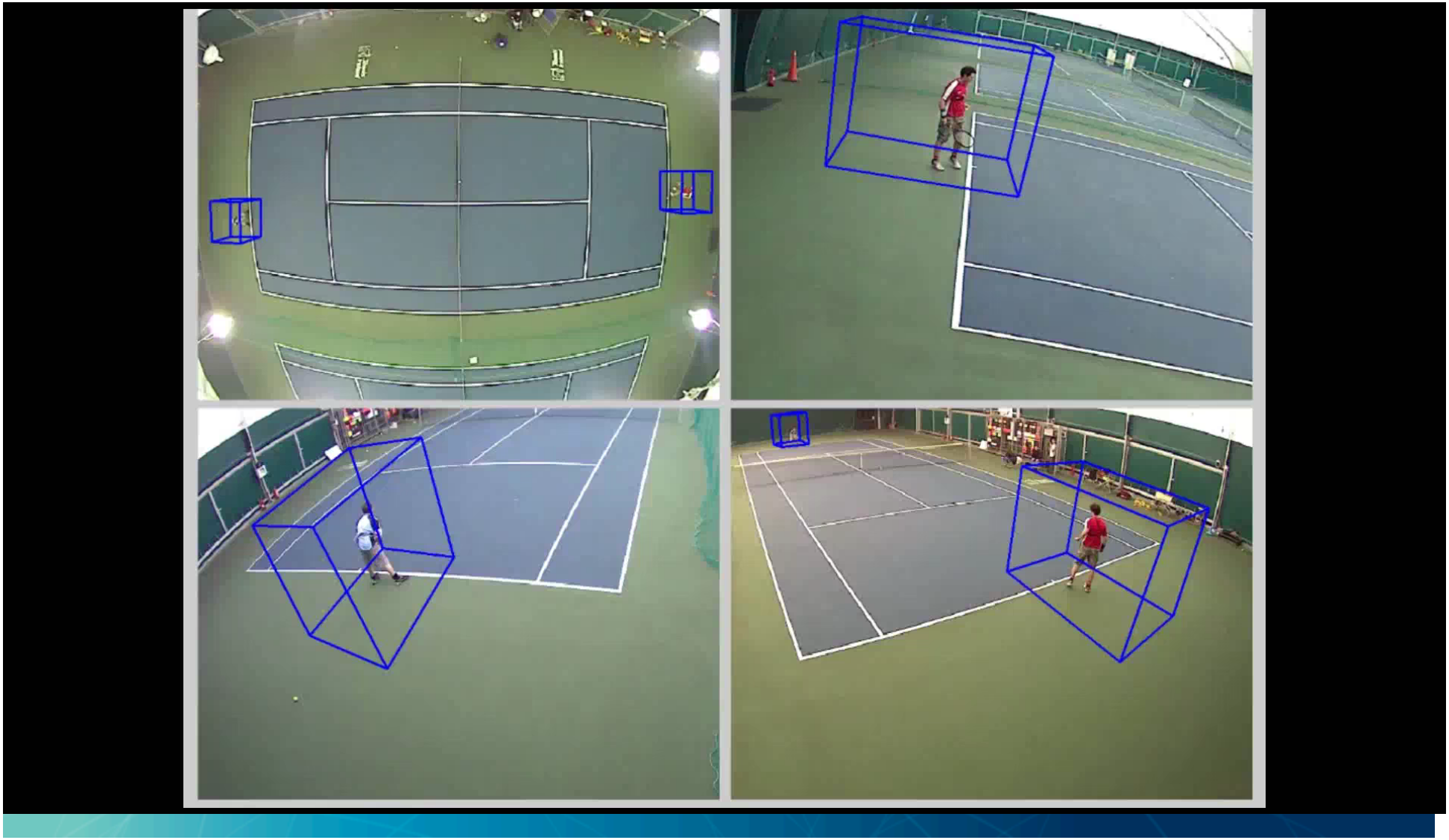
New media: Motion capture

Kelly et al, Computer Graphics Forum, 32: 48–60

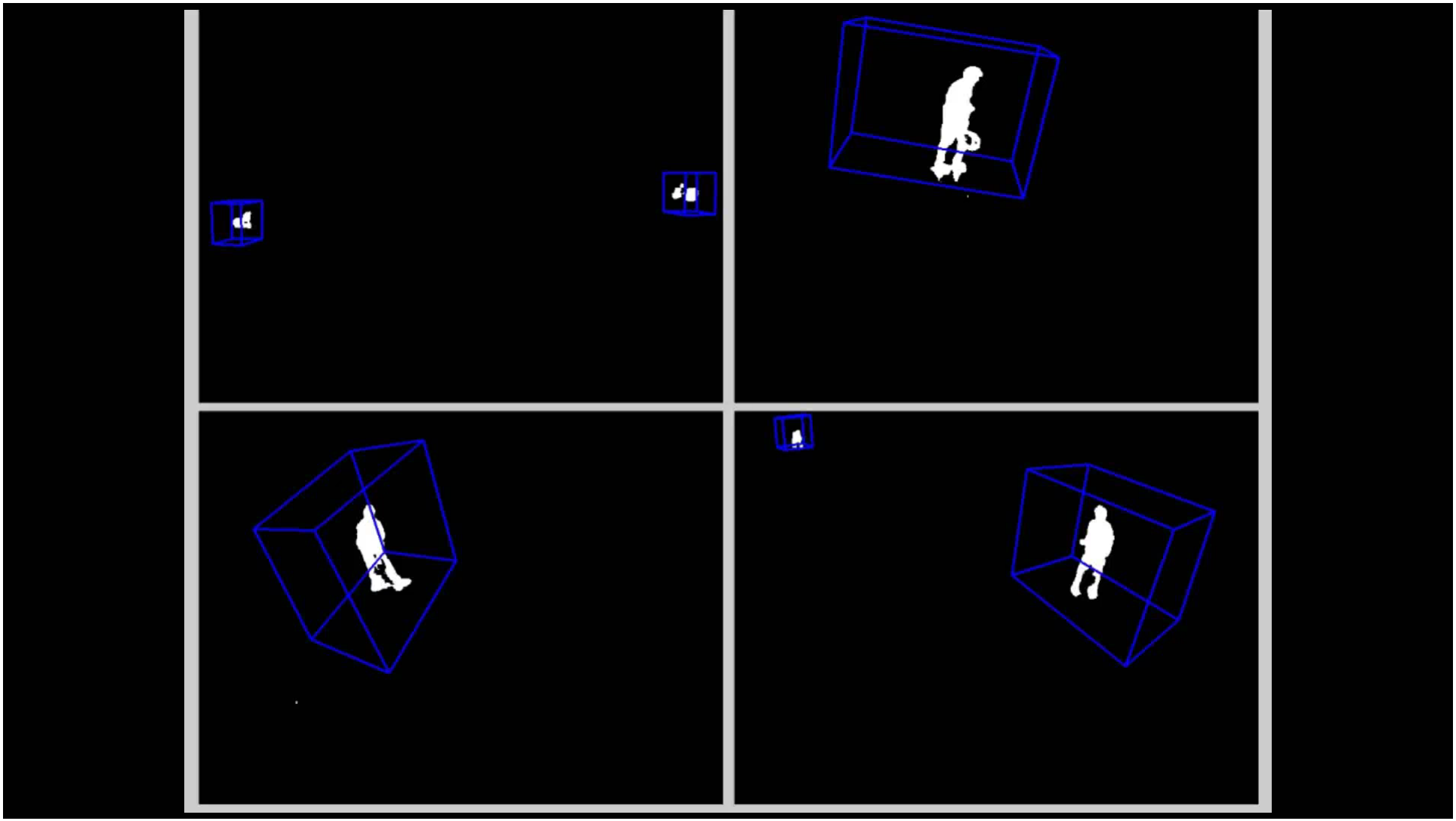


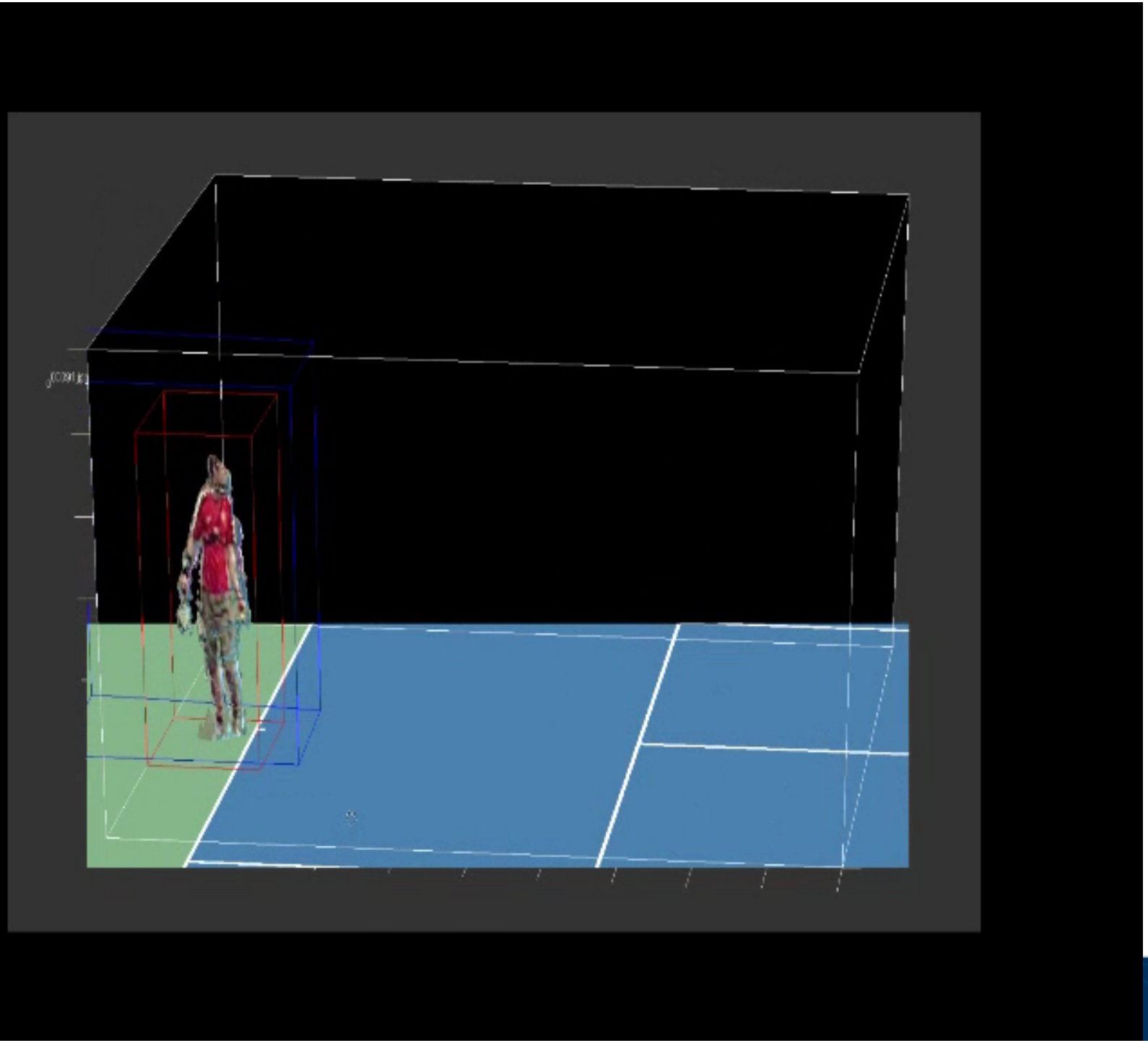
New media:
3D reconstruction

Jimenez M.J. et al, Computer Vision and Image Understanding (in press)

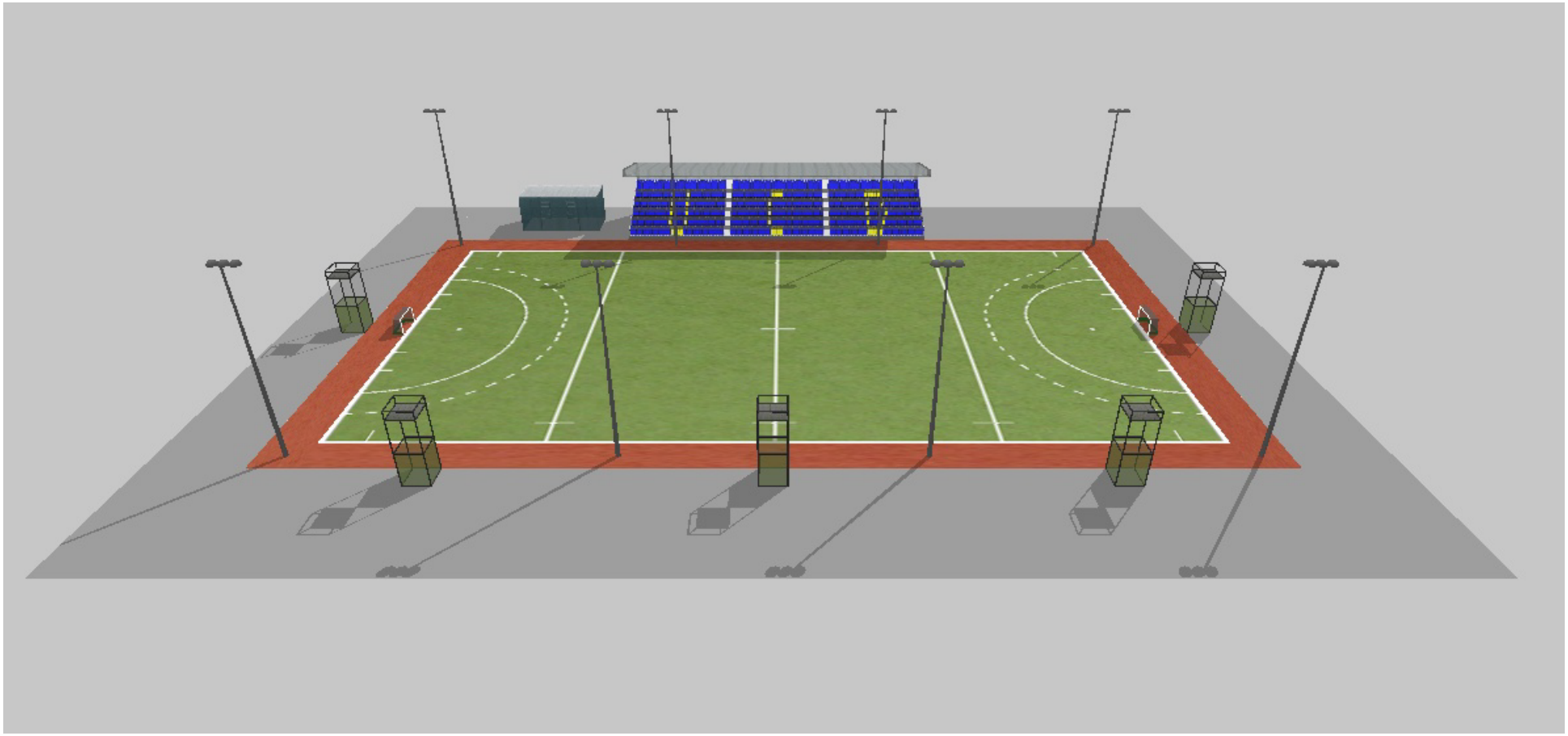


New media:
3D reconstruction





Installation at national hockey facilities



Installation at national hockey facilities

“Living lab”

Regular global webcasts of high profile events

To be used for prototype development & trial deployment

Full pitch-perimeter underground ducting system
Production Hub Cabin
Live-Streaming Capabilities
3 x Remote Control Sony Broadcast HD Z-700 cameras
Panasonic 6way HD-SDI video mixer deck
4 x Pitchside Mics
2 x Commentator Mics
Cat5e Network
Video crew

Personal Highlights

Personalised video for each player on team after match

Highlights based on actions/activity

Or speed, respiration, heart rate, ...

Wearable sensor placed on each player

We use mobile phone (GPS + accelerometer + WiFi)

Anyone can participate!

Personal Highlights

Overall Approach

Recognise Player Activities

Recognise Team Activities

Extract Highlights

Player Activity

Use accelerometers in phones

Onboard storage or wireless transmission

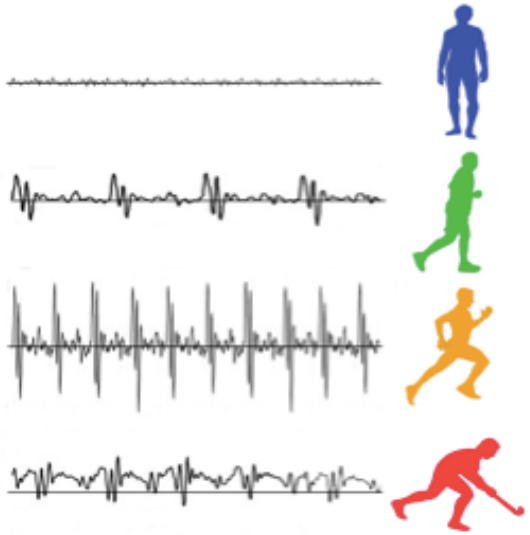
Access to embedded GPS

Used to classify game events

Standing, walking, running

tackling, shooting, saving

fouls, frees



Similar to “stroke classification” for tennis

Mitchell et al, Sensors 13 (4), 5317-5337

Player Activity

5 matches recorded
3HD cameras
6 hours of video

18 players logged
15 outfield, 3 keepers

Stationary:	95%
Walking:	100%:
Jogging:	95%
Sprinting:	88%
Tackling:	78%
Pass:	63%
Shoot:	15%

Outfield players:
Stationary, walking, jogging, sprinting, tackling, pass, shoot, receive short corner

Keepers
Stationary, walking, jogging, dive, block, pass

Player Activity

Team Activity

Direkoglu & O'Connor, ICIP 2012: 2693-2696

Automatically recognize

Attack (slow or fast, counter attack, short corners)

Defence (slowly returning, fast return)

Time out (play stopped)

Based on knowing player positions

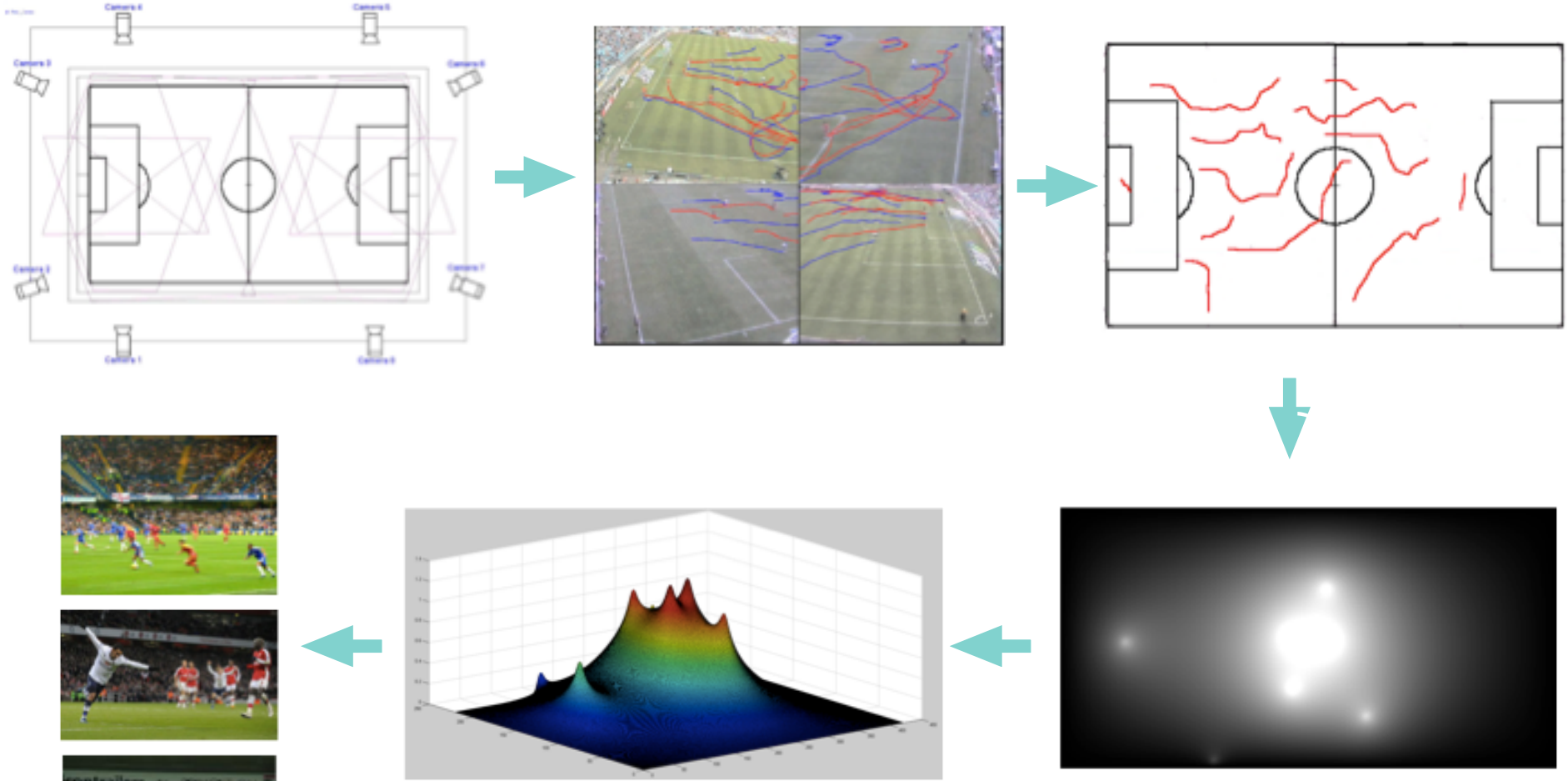
From GPS, cameras + image processing, RF-ID, ...

Most localisation systems are inaccurate!

Our approach

Only need approximate (best guess) location information

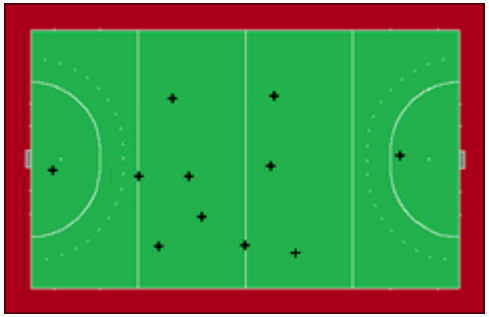
Team Activity



Direkoglu and O'Connor, ECCV (7) 2012: 69-83

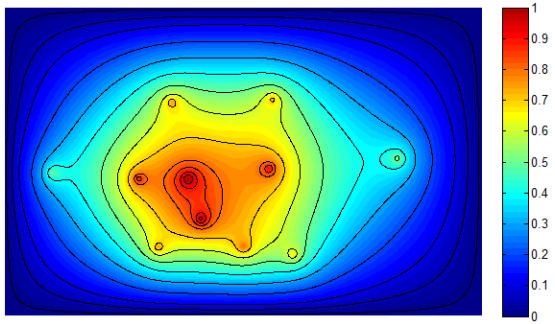
Also “region of intent”

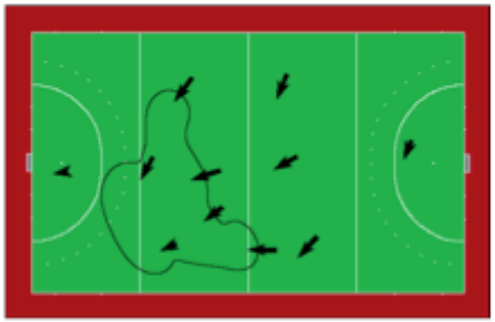
We solve a particular Poisson equation to generate a position distribution for the team



$$\nabla^2 \mathbf{I}(x,y) = -\left(\sum_{i=1}^{N} \delta(x - x_i, y - y_i) \right)$$

$$\mathbf{I}(x,y) = 0$$

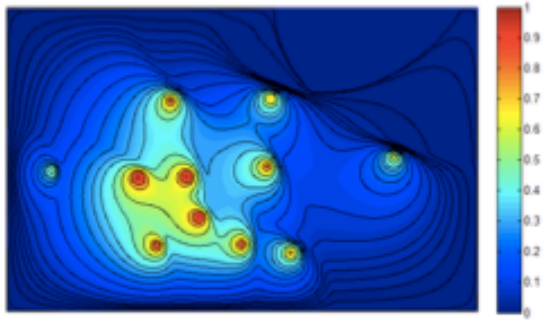




Team movement

$$ID^n = \sum_{i=1}^{N} \left(I_i^n - I_i^{n-m} \right)$$

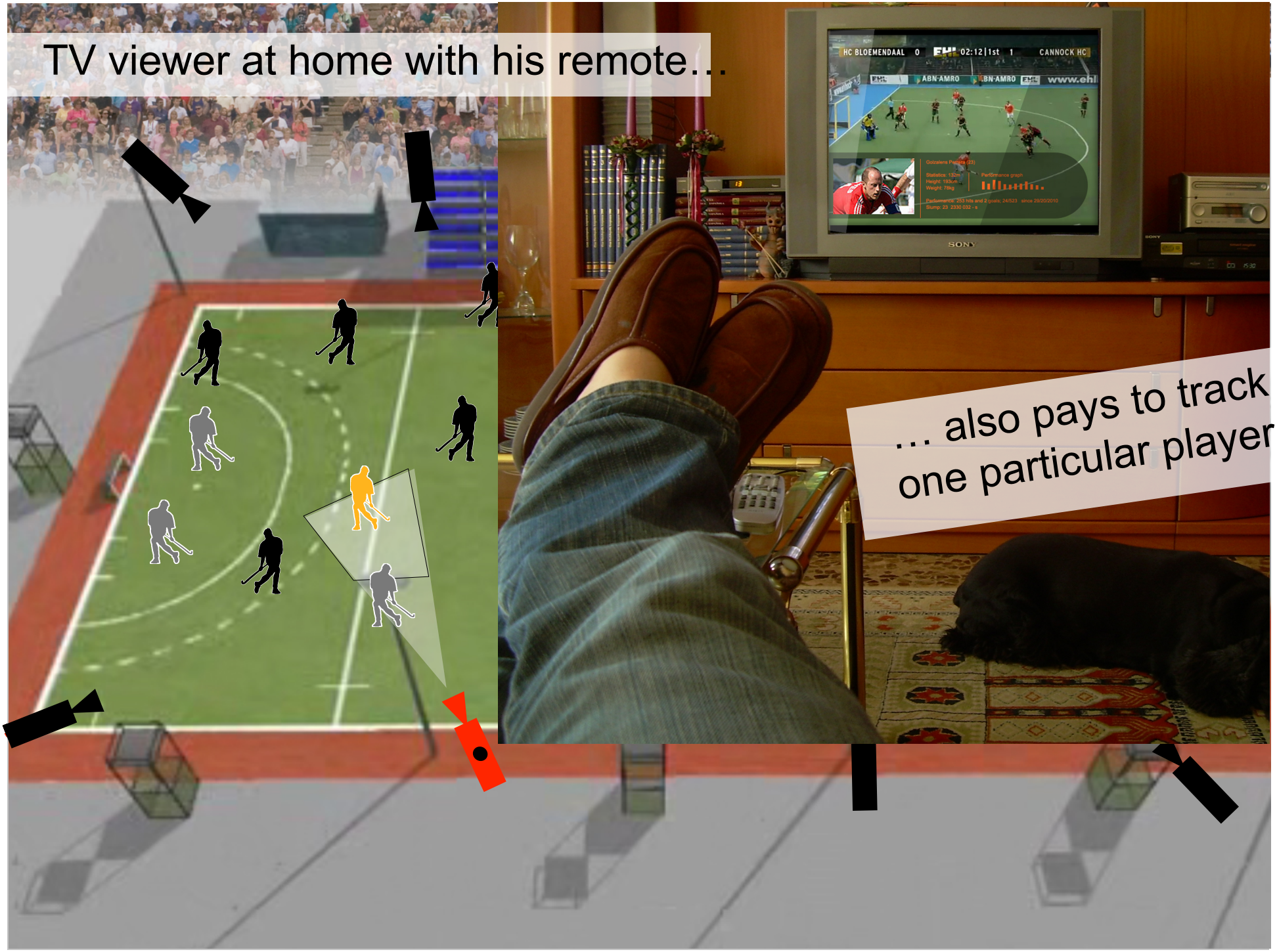
where $\forall \left(I_i^n - I_i^{n-m} \right) > 0$



Intention distribution of the team

Team Activity

Team Activity


TV viewer at home with his remote…
HC BLOEMENDAAL 0
02:12 | 1st 1
CANNOCK HC
ABN-AMRO
ABN-AMRO
www.ehl
SONY
… also pays to track one particular player

The Quantified Self

Water quality monitoring

MESTECH
Marine & Environmental Sensing Technology Hub

1st Generation Sensor

Environmental monitoring involved manually collecting samples.

Labour, travel, human error, costly, restricted, hard to reach areas, scale

Water quality monitoring

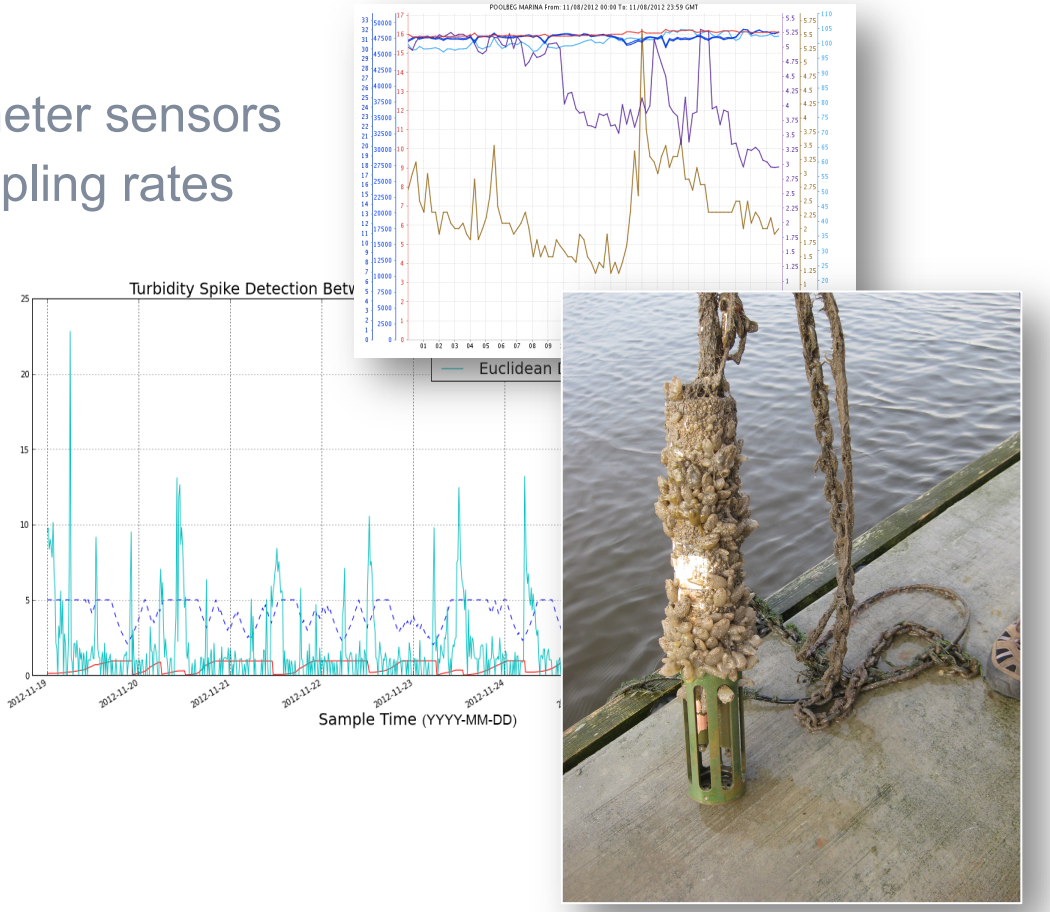
MESTECH
Marine & Environmental
Sensing Technology Hub

2nd Generation Sensor

Wireless autonomous multi-parameter sensors

Lack of “Ground Truth”, static sampling rates

Unreliable, bio-fouling, scale



Water quality monitoring

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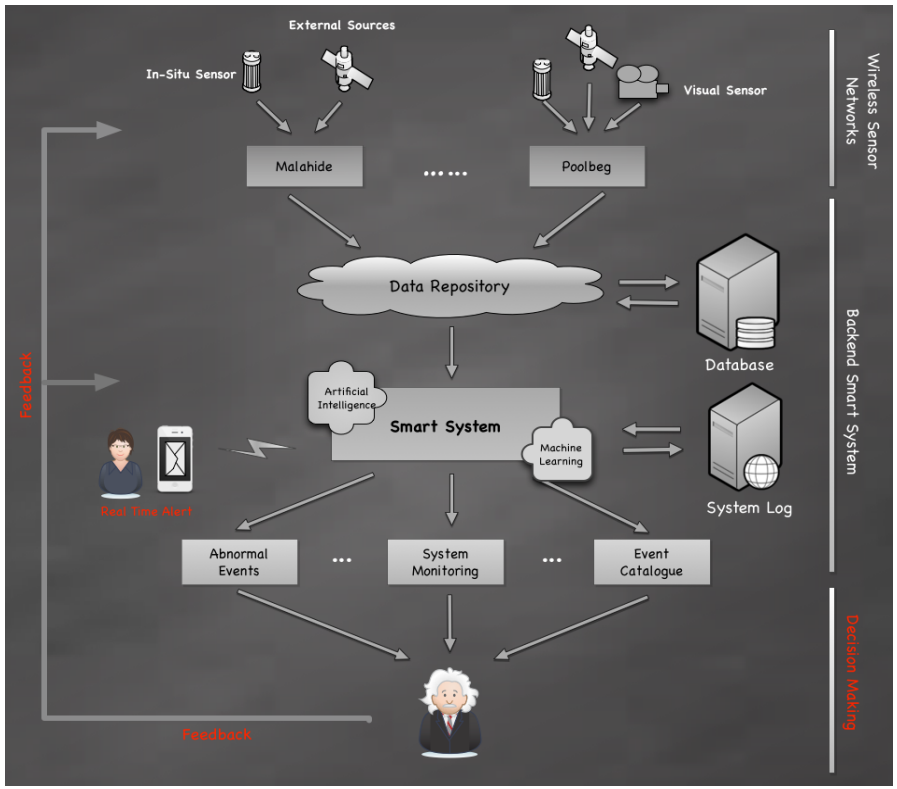
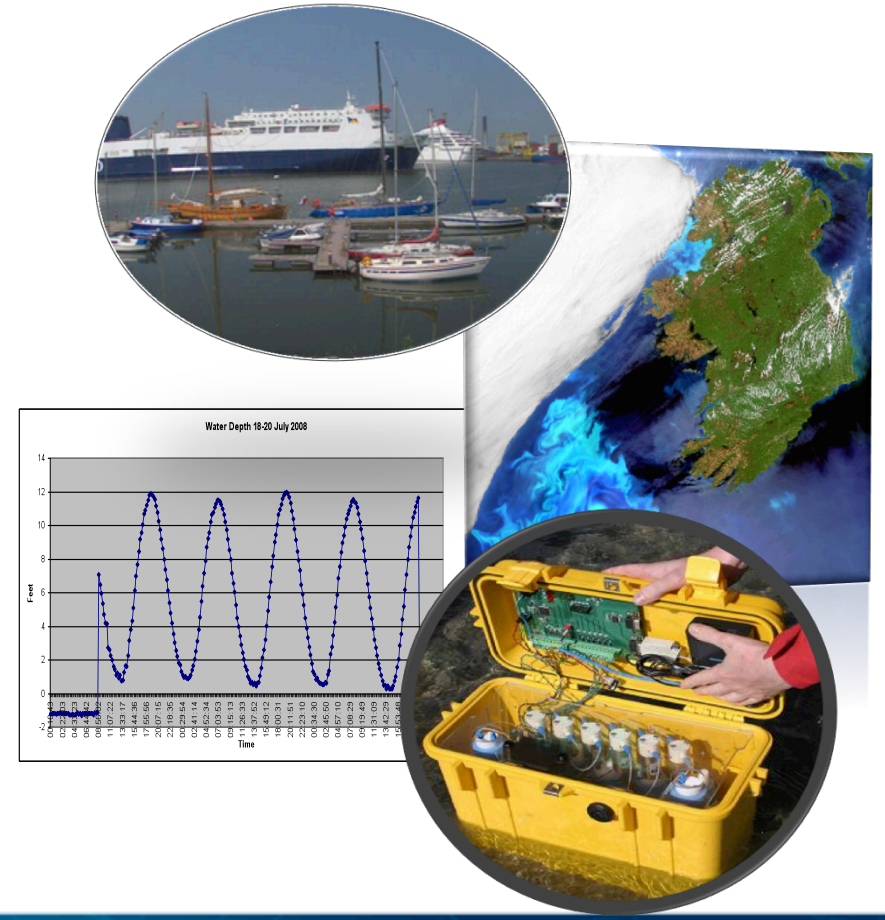
3rd Generation sensor network





Water quality monitoring

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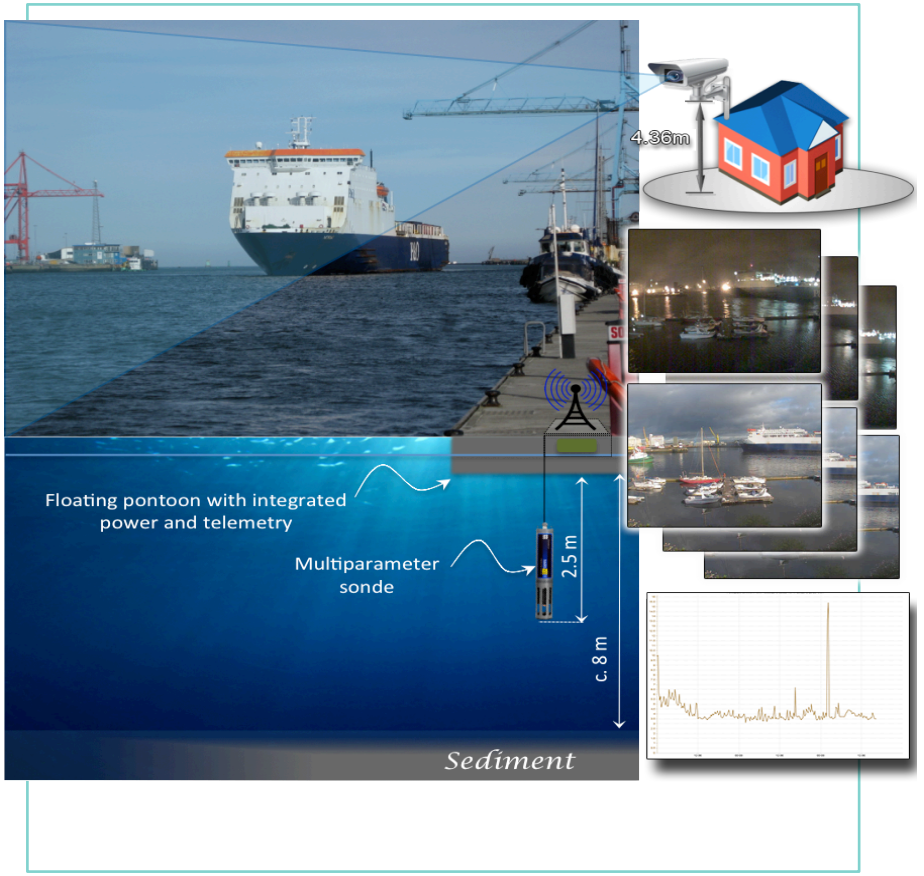
Water Quality Prediction

Salinity

Anomaly Detection

Turbidity

Shipping Trajectory Detection



Zhang et al, "A visual sensing platform for creating a smarter multi-modal marine monitoring network", MAED 2012

Water quality monitoring

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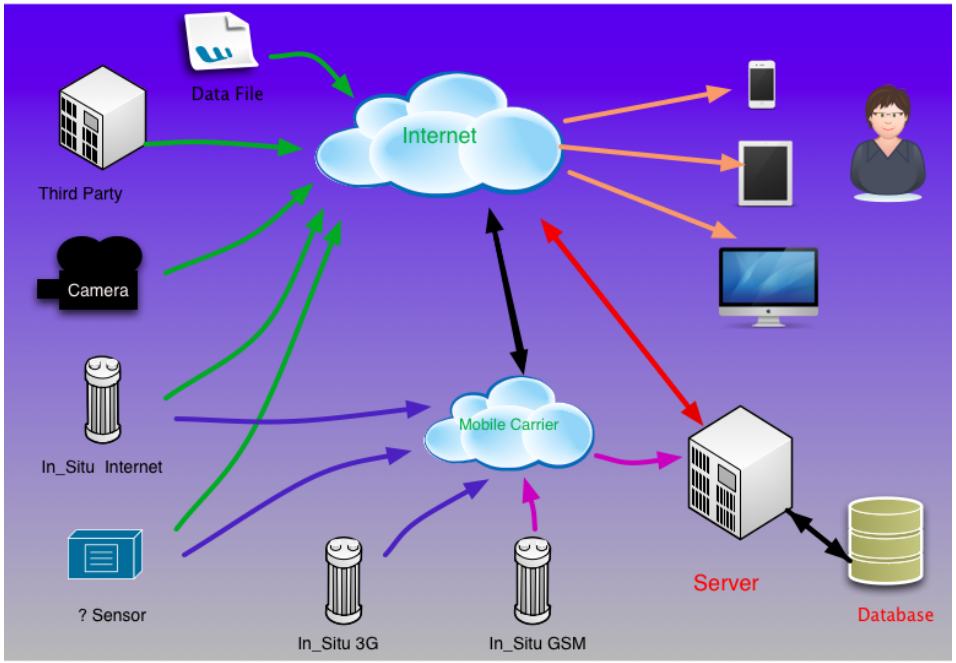

(a) (b)

Conclusion

Sensor Web vs. traditional media analysis

Still identifying media fragments for re-use, but new use cases?

Greater granularity of understanding possible?

Individual & team activity classification

More opportunities for personalised feedback?

Individual highlight reel based on what you did in a game

Team-based analysis and statistics for coaches / trainers

New types of mediafragments available

Synthesized or reconstructed content

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