Automatically Providing Effective Memory Retrieval Cues

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Centre for Digital Video Processing (CDVP) &
CLARITY: Centre for Sensor Web Technologies,
Dublin City University

Overview

- **BRIEF OVERVIEW OF OUR RESEARCH CENTRE**
- OUR UNDERSTANDING OF MEMORY CUES
- AUTOMATED PROCESSING TO SUMMARISE SENSECAM DATA
  - Segmenting sequences of Images into Events
  - Retrieval of Similar Events
  - Determining Important Events
  - Selecting Optimal Keyframe
  - Augmenting Events
- CONCLUSIONS

CLARITY [1/3]

CLARITY: Centre for Sensor Web Technologies

- Recently announced CSET (Centre for Science Engineering & Technology)
- Funded by Science Foundation Ireland (SFI) with industry contributions
- 5 year duration, following on from previous 4-year "Adaptive Information Cluster"
- Administrative centre in UCD, researchers in DCU, UCD and Tyndall Institute
- Within DCU involves CDVP (Computing & EE), NCSR, Health & Human Performance

CLARITY [2/3]

CLARITY What ? “The Sensor Web”

- Increasing availability of cheap, robust, and deployable sensor technologies ushering in a wave of new information sources;
- Ubiquitous, dynamic, noisy, reactive and yielding unstructured data-streams == sensor web
- Realizing the sensor web demands a large-scale, multi-disciplinary research effort == CLARITY
- Moving beyond our research silos to novel research interactions;
- Demonstrator projects in:
  - Personal health and wellness;
  - Environmental monitoring;

CLARITY [3/3]

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Principal Investigators

Prof. Barry Smyth	- *Personalization, recommender systems, mobile computing*
Prof. Alan Smeaton	- *Content-based information retrieval*
Prof. Dermot Diamond	- *Materials research, wearable sensors*
Prof. Noel O'Connor	- *Audio-visual analysis, multi-modal information processing*
Mr. Gregory O'Hare	- *Ubiquitous computing, multi-agent systems*

Associate PIs

Prof. Paddy Nixon	- *Pervasive computing, middleware, security, trust, privacy*
Prof. Niall Moyna	- *Sports Science, wearable sensing*
Dr. Simon Dobson	- *Middleware, pervasive computing*
Dr. Cian O'Mathuna	- *Sensor devices, energy-aware hardware*
Dr. Brian Caulfield	- *Physiotherapy, therapeutic gaming, wearable sensors*

Funded Collaborators

Chris Bleakley (UCD), **Conor Brennan (DCU)**, Rem Collier (UCD), **Brian Corcoran (DCU)**, **Cathal Gurrin (DCU)**, Neil Hurley (UCD), Lorraine McGinty (UCD), **Kieran Moran (DCU), Kieran Nolan (DCU)**, Brendan O'Flynn (TNI), **Donal O'Gorman (DCU), Brett Paull (DCU),** Emanuel Popovici (TNI), Aaron Quigley (UCD), **Mark Roantree (DCU)**

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  - Augmenting Events … Norman Alm
- CONCLUSIONS

Memory Systems of Interest

- SENSORY
- SHORT – TERM
- LONG – TERM
  - –PROCEDURAL
  - –DECLARATIVE
    - Semantic
    - EPISODIC/ **AUTOBIOGRAPHICAL**
      - – **"Cued Recall" better than "Free Recall"** *(Purdy, '01)*
      - – **Encoding has strong effect on retrieval** *(Godden, '75)*

Cued Recall & Visual Encoding

- Visual encodings are very strong *(Brewer, '88)*
- Encoding from same perspective/environment as viewer is powerful *(Vargha-Khadem, '01)*
- Memories can be temporally encoded *(Larsen, '96)*
- Distinct memories are more strongly encoded *(Purdy, '01)*
- Memories stored by association *(Baddeley, '04)*

Our Take…

To effectively provide memory retrieval cues using SENSECAM we need to automatically:

- *"Chunk" similar images into distinct events*
- *Suggest more "distinctive" events*
- *"Associate" related events*
- *Provide potentially additional retrieval cues from other sources*

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Daily Browser Overview

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SenseCam Images of a day (about 3,000)

Event Segmentation

Event-Event Comparison within the Multi-day Event database

2 Sept 06

Interactive Browser

Event Augmentation

Day -1
Day -2
Day -3
Day -4
Day -5
Day -6

Event database containing last 7 days' Events

Novelty Calculation of Each Event

0.1 0.7 0.1 0.1 0.3 0.4 0.8 0.1 0.9

Landmark Image Selection

Composition of the Browser

Event Segmentation

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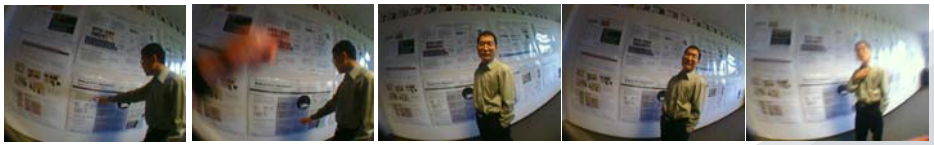
Breakfast

Work

Car

Talking to colleague



Airplane

Event Segmentation

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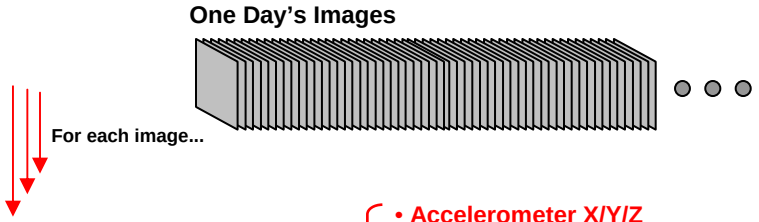
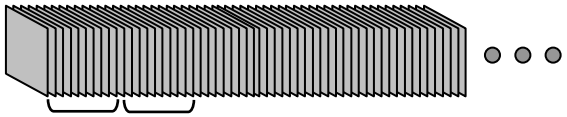
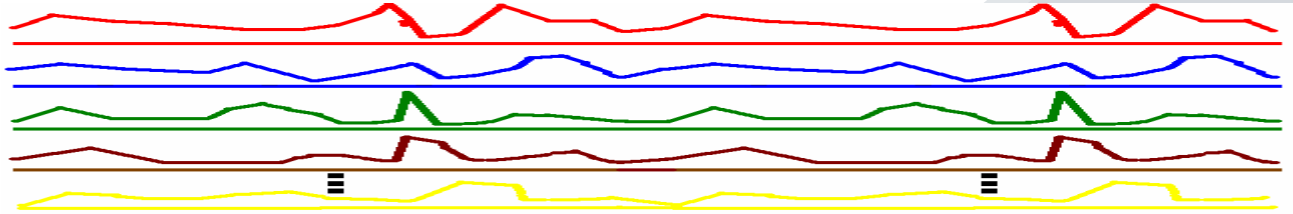
Raw data



Similarity matching

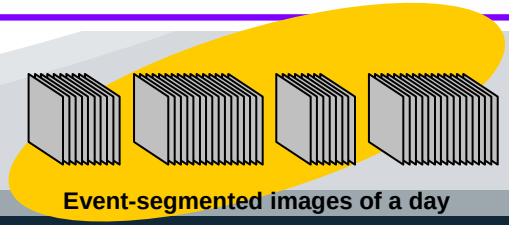


Normalisation & Data fusion



Thresholding

Events



How well does it work?

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Data divided into training and test sets with thousands of different combinations evaluated

From groundtruth we noticed:

Average of 1,785 images per user per day
Average of 22 events groundtruthed per day

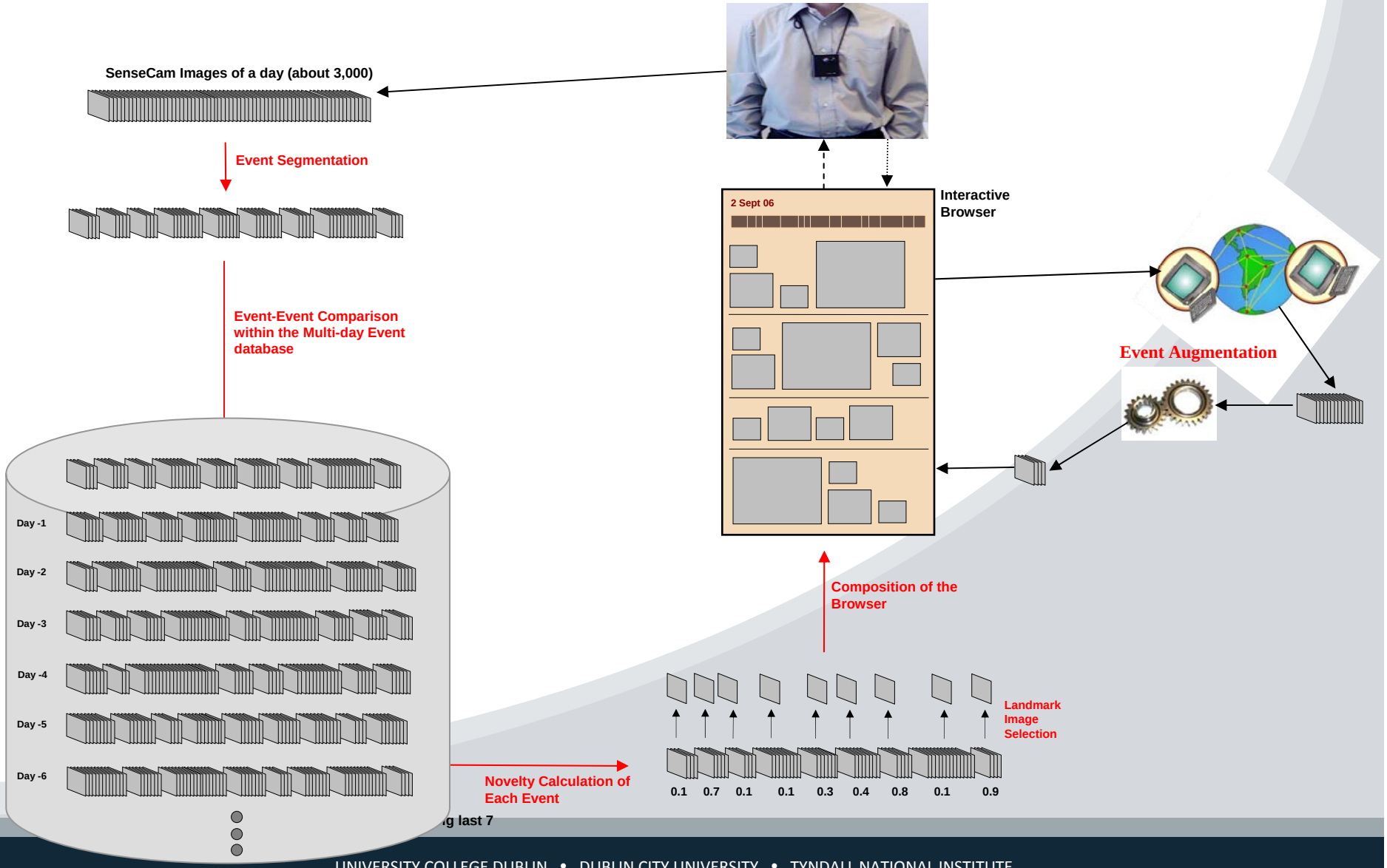
Approach Recommended:

Quick segmentation (sensor values only)

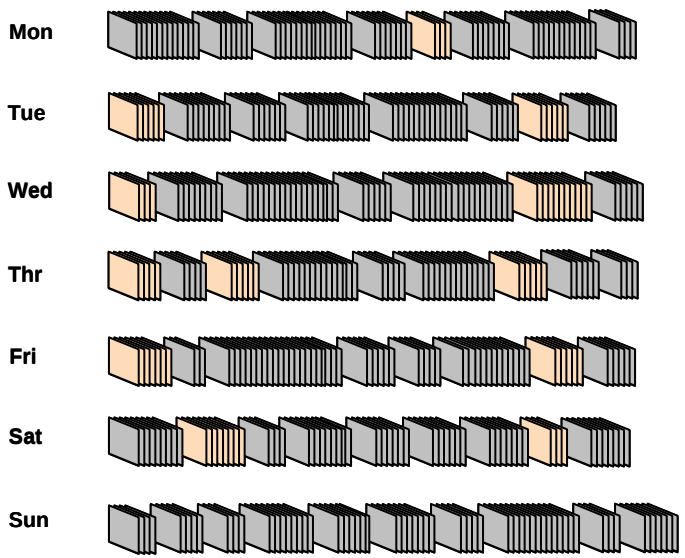
Performance:

Approx. 60% against *users' semantic* boundaries

Retrieval Reminder



Finding similar events



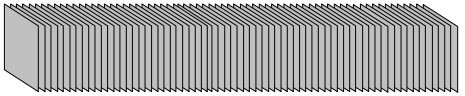
Storing by association

- Events are represented by the average values of all the images present in that event

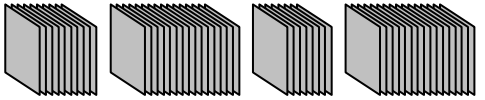
- Investigated numerous computation approaches to match similarity of any two given events

Event Retrieval

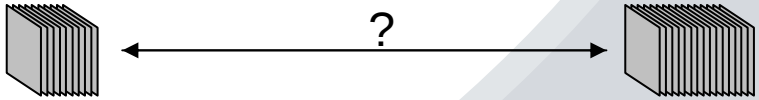
1. Day of ~2,000 SenseCam images



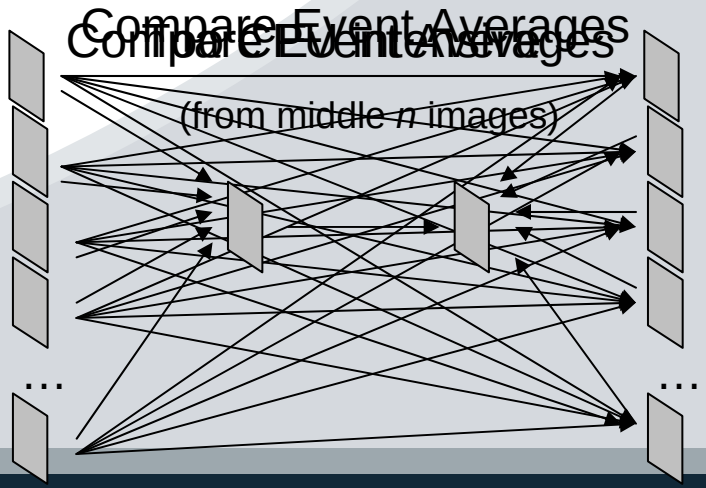
2. Segmented into ~20 events



3. How to compare events to each other?



4. How do we represent events?

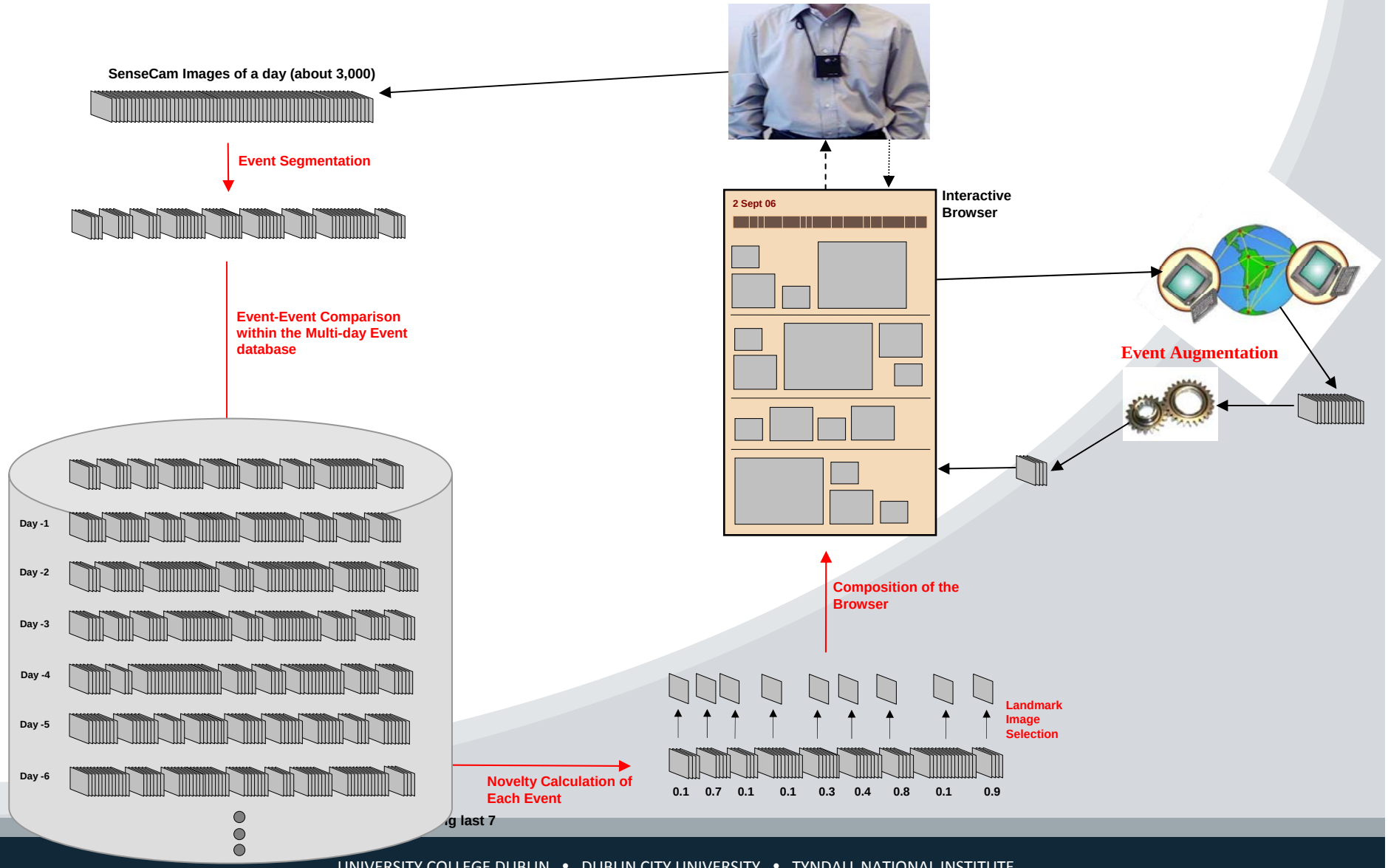


How accurate is it?

Again thousands of combinations investigated in training phase

- **Event retrieval works well for general queries (69% accuracy of top 5 results)**
  - Can help to remove “clutter” of everyday events from visual diary
- **Retrieval for specific events much more challenging (30% accuracy of top 5 results)**
  - Less events in the collection, lack of semantic meaning
- **Query scores ranging from 0.6% (talking to Lynda) to 94% (Michael at work on his PC)**

Importance Reminder



Importance

- Greater emphasis is placed on important events

- Routine/mundane events can be hidden

Distinctive memories encoded strongly

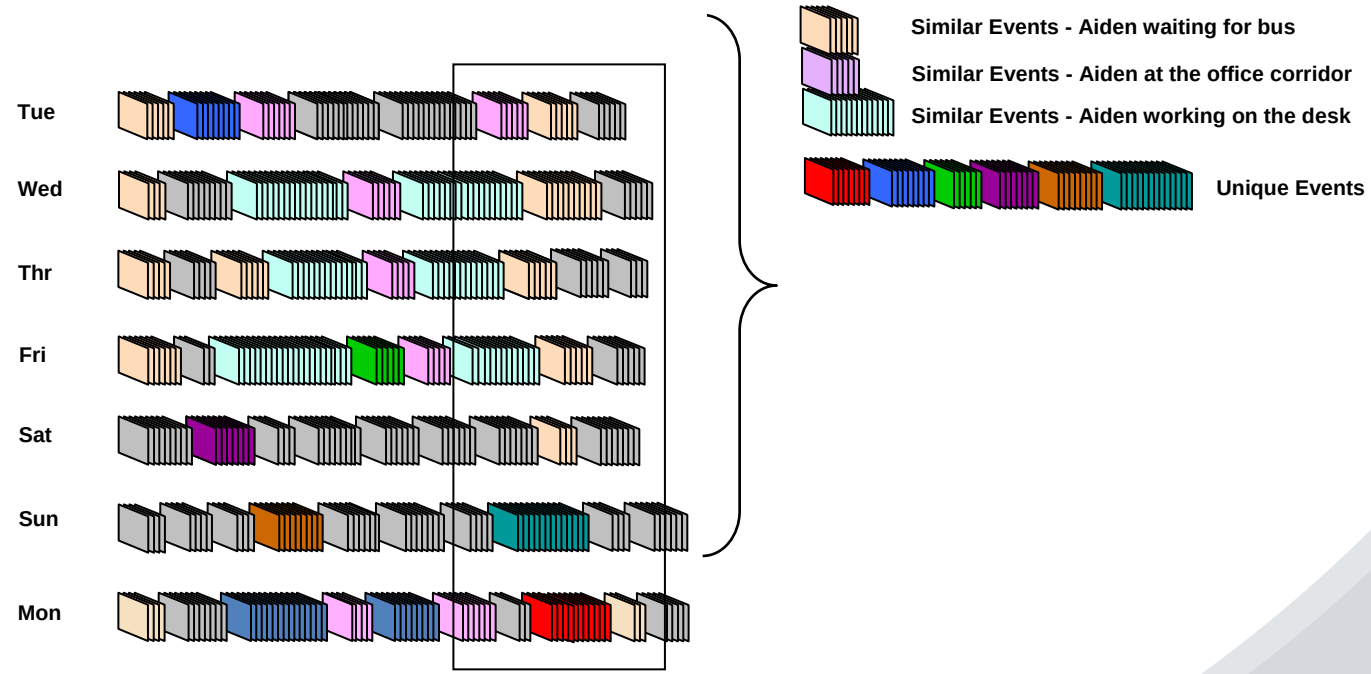
Automatic Face Detection

Trained on set of 1,758 SenseCam images

SenseCam images are low quality

Accuracy = 63%

Novelty to Detect Importance



- Find the most dissimilar event of today by taking the previous 2 weeks into account.

- Also for any event, we only look at how novel it is with respect to events around the same time from other days

< October 2006 >

Mon	Tue	Wed	Thu	Fri	Sat	Sun
25	26	27	28	29	30	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

Would you agree that the top 2 events were among the most interesting in your day, and the bottom two were among the least interesting in your day?

- 5 - Strongly Agree
- 4 - Agree
- 3 - Neutral
- 2 - Disagree
- 1 - Strongly Disagree

99% complete!

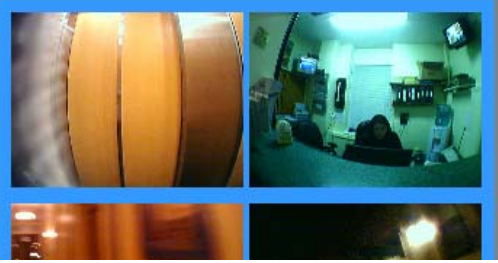
Log Out

Most Important Event

2nd Most Important Event

2nd Least Important Event

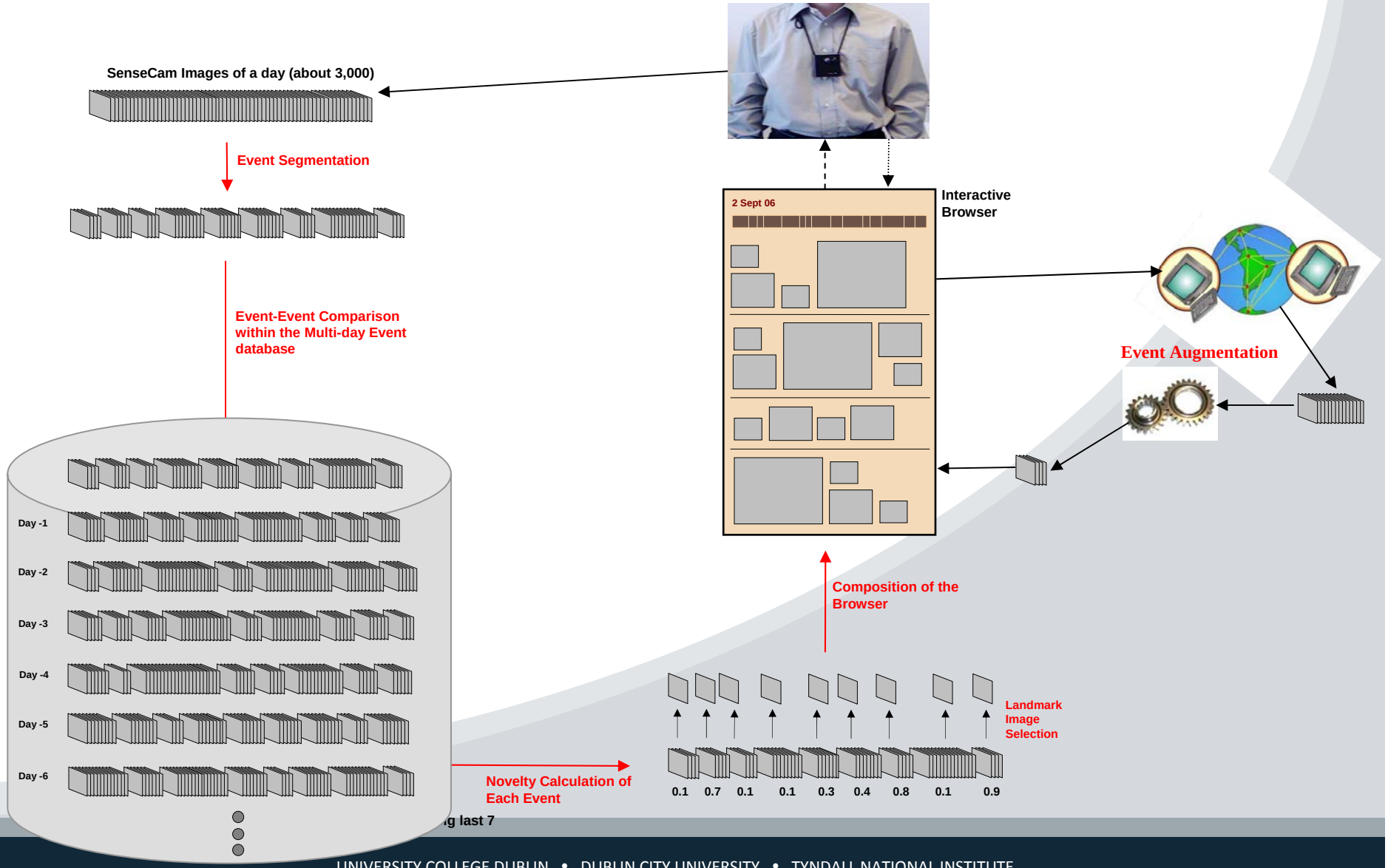
Least Important Event



How well does it work?

- Face Detection good at highlighting most important events
- Novelty good at detecting routine events
- Median Likert score of 4/5, so users generally satisfied

Keyframe Reminder



Keyframe Selection

Standard Approaches

- Middle Image
- Image Quality
- Image closest to others in same event
- Image that distinguishes event best from other events

Keyframe Experiments

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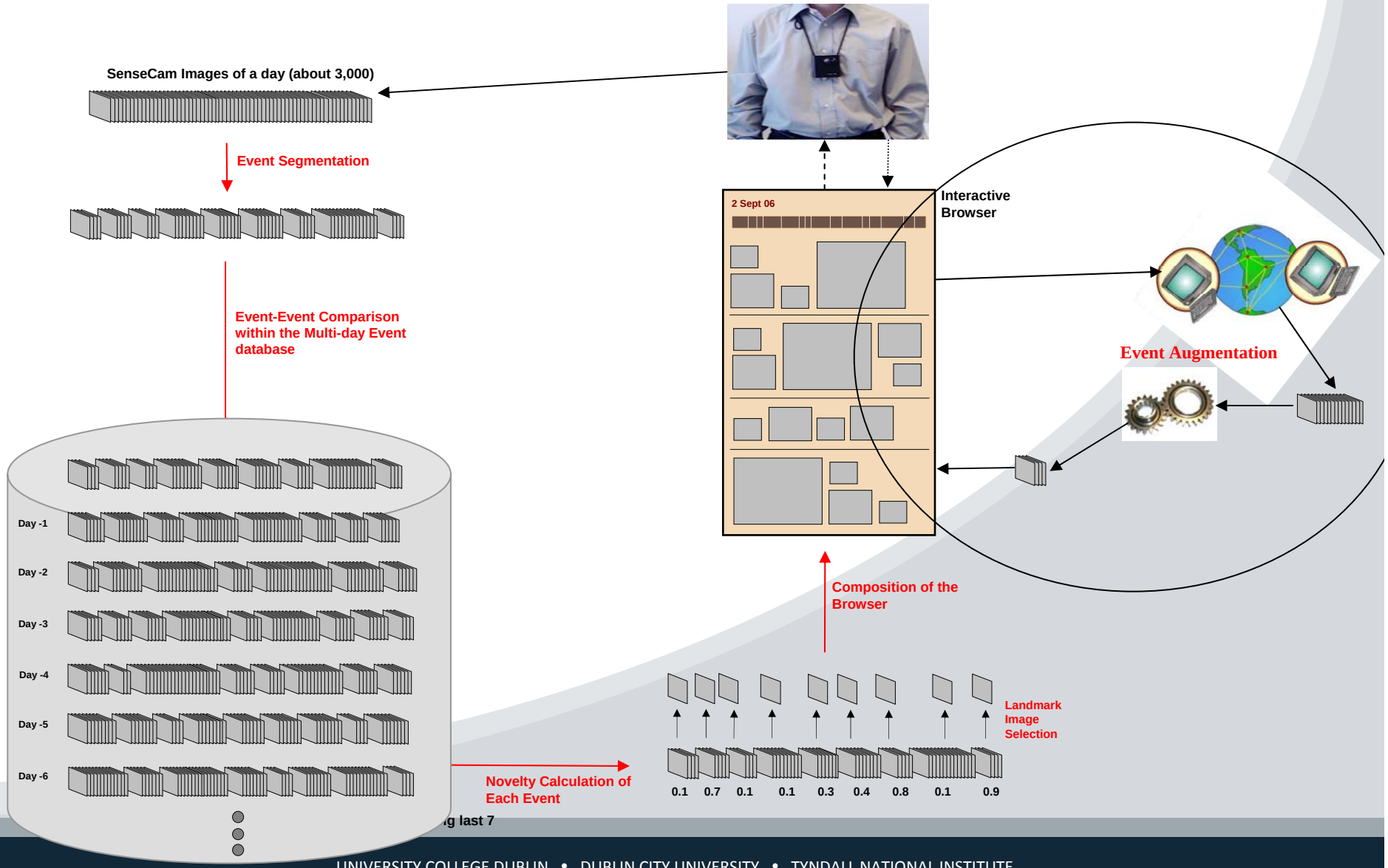
How well does it work?

- User judgements made on 2,235 events
  - 6 keyframes judgements per event
  - providing a groundtruth of 13,410 judements

- Selecting highest quality image works best, although selecting middle image is also effective

Augmentation Reminder



Event augmentation

Here's a SenseCam picture of me at a pier in Santa Barbara, CA.

If I have GPS I can search for other pictures in the same location…

Event augmentation

- I receive the following “geotagged” images…
- Then after some clever processing on text associated with these images we get many more images, and even YouTube videos at times too!








Augmentation

How well does it work?

- 11 users collected 1.9 million images
  - from that selected 67 events to augment
- Users very satisfied with augmentation results of famous tourist locations e.g. ground zero
- Specific events still a challenge e.g. FA Cup Final

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Conclusions

- Event Segmentation is pretty accurate, and VERY fast

- Event Retrieval is good for most queries and helps direct the user to “associated/related” events

- Suggested Keyframes are on the whole a good approximation of nearly all events

Conclusions

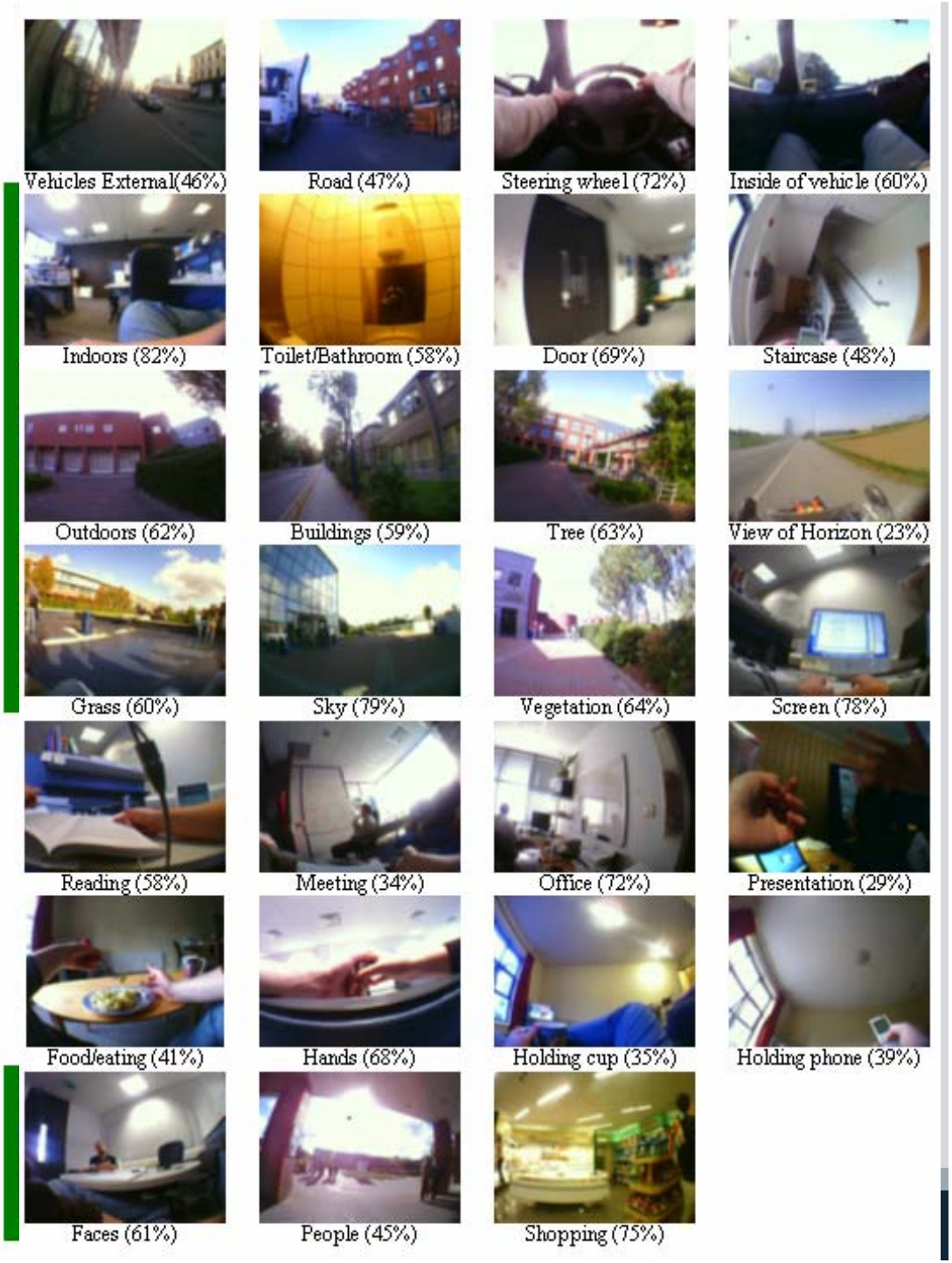
- Determining event importance generally provides a good “starter cue”

- Augmentation provides many additional images and is especially useful when visiting big tourist sites

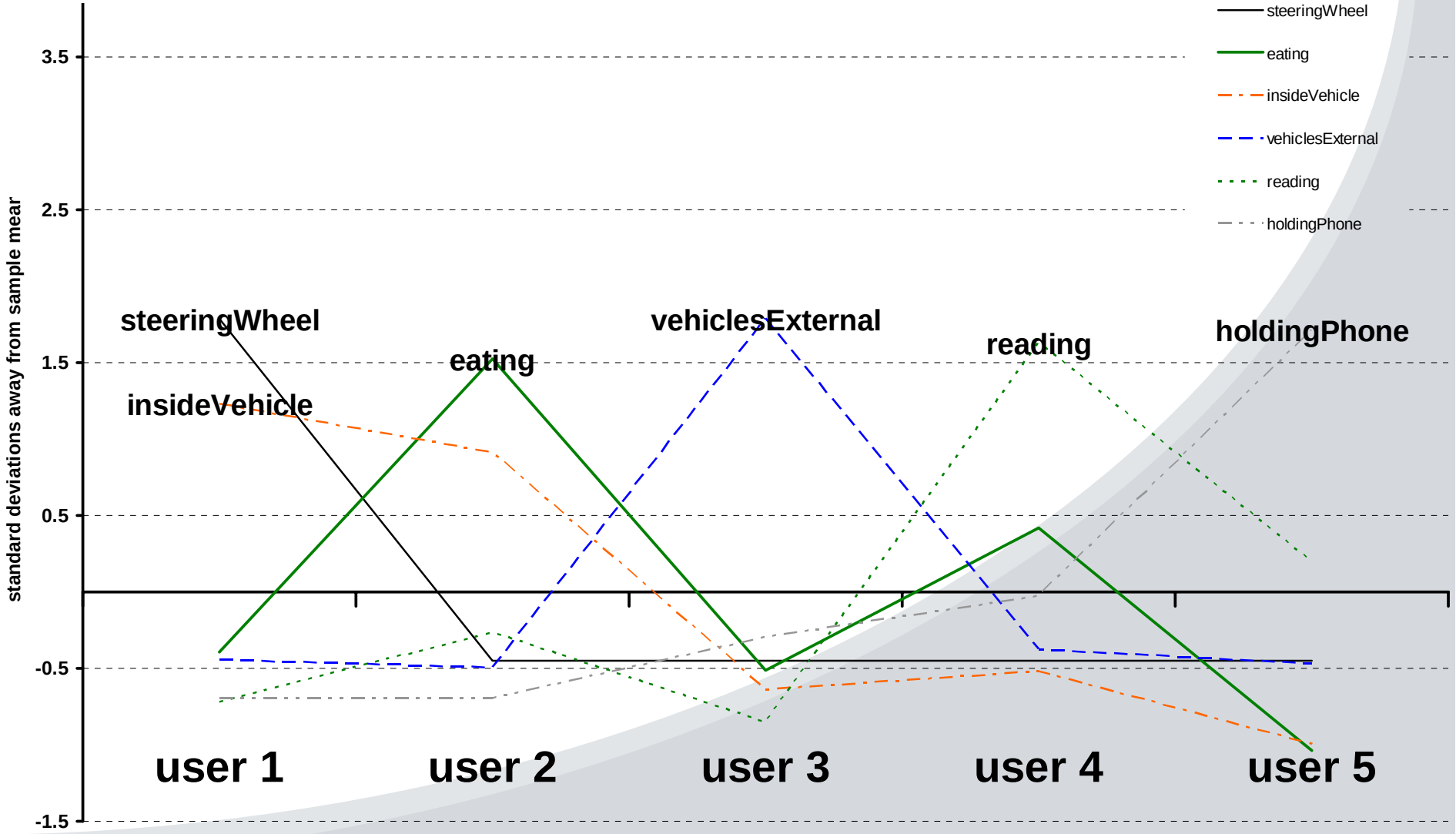
Future Work

Activity Recognition

27 “concepts”



Future Work


steeringWheel
eating
insideVehicle
vehiclesExternal
reading
holdingPhone
standard deviations away from sample mear
3.5
2.5
1.5
0.5
-0.5
-1.5
user 1
user 2
user 3
user 4
user 5

Thank You

further information:

http://www.cdvp.dcu.ie/SenseCam