Content vs. Context for Multimedia Semantics: the Case of SenseCam Image Structuring

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Contents

- Overview … Contents & Contexts for IR
- Examples of C&C for IR applications
- The SenseCam definition, background and applications;
  - SenseCam usage issues;
  - Structuring SenseCam images;
  - Determining event importance;
  - User interface to a lifelog of images;
- Content & Context … it's now the default for information management !

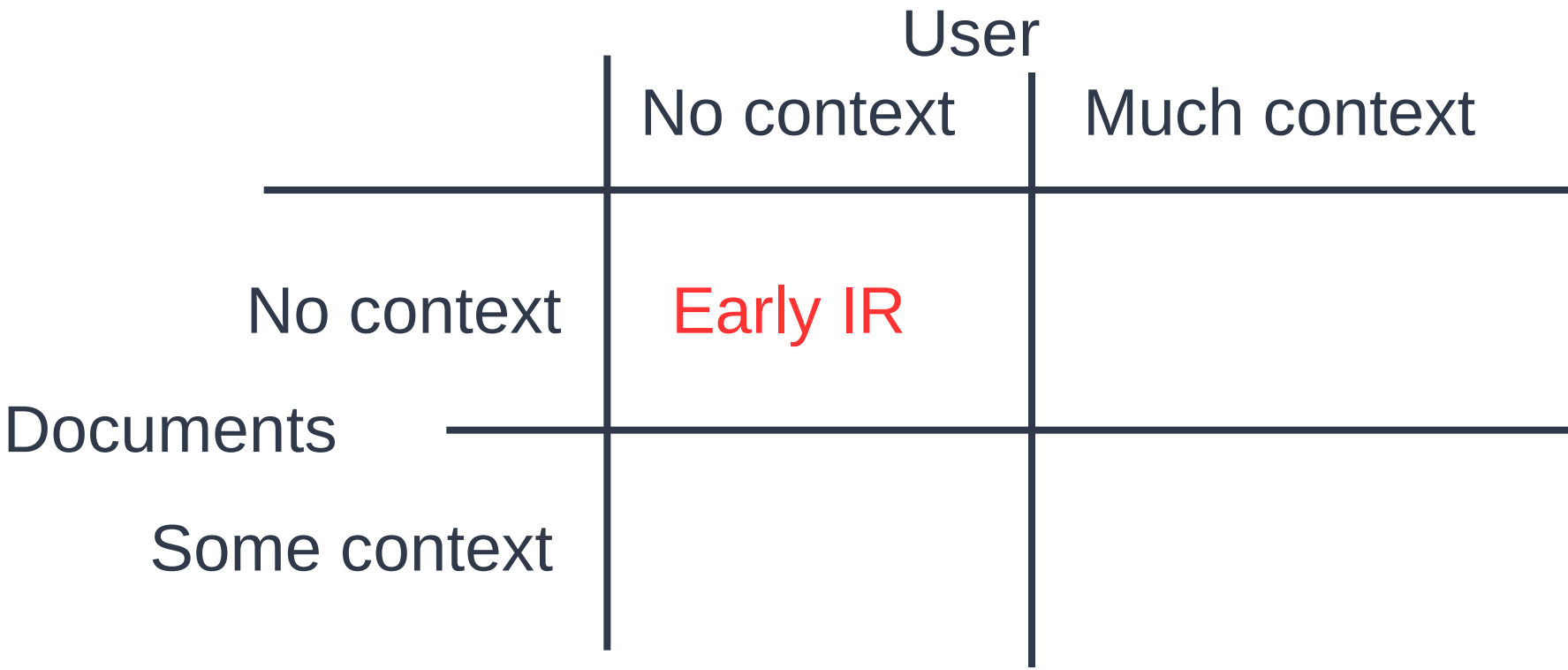
Content / Context

- Good information access is about knowing who is seeking information, what they already know, why they search, what they want to do, by when, other constraints, etc.;
- This is user context;
- Good IR systems know much about their information, can find similar information, know about related information, know about other resources, can use a range of modalities & can package their outputs;
- This is "document" context;
- Great information access combines user context and user information needs with document context and document content, matching them all;

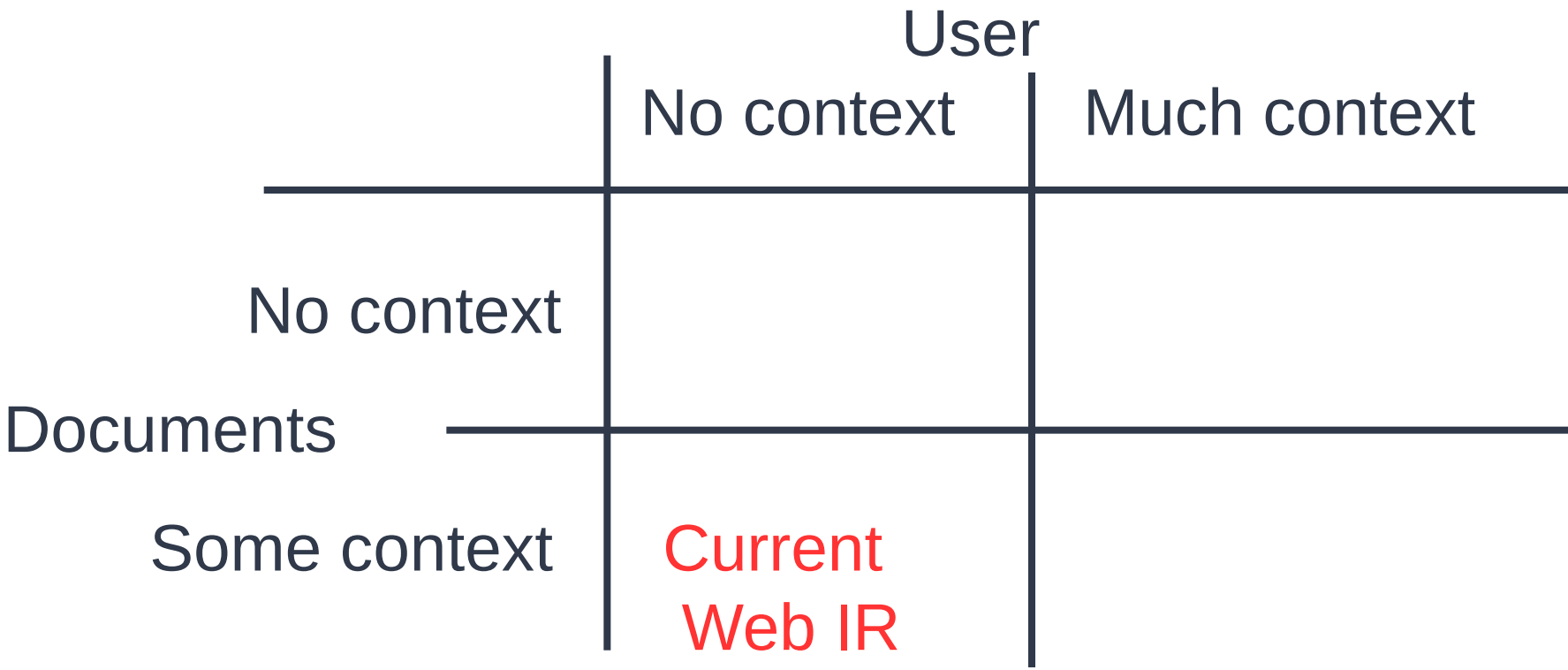
- The search engine application is to locate “things” which are similar to my query;
- … but the retrieval scenario … locate “things” which are relevant to me now;

- Knowing this is not new and this is where the white heat of IR research is at … figuring out what user context is, how to capture it, and what to do with it;

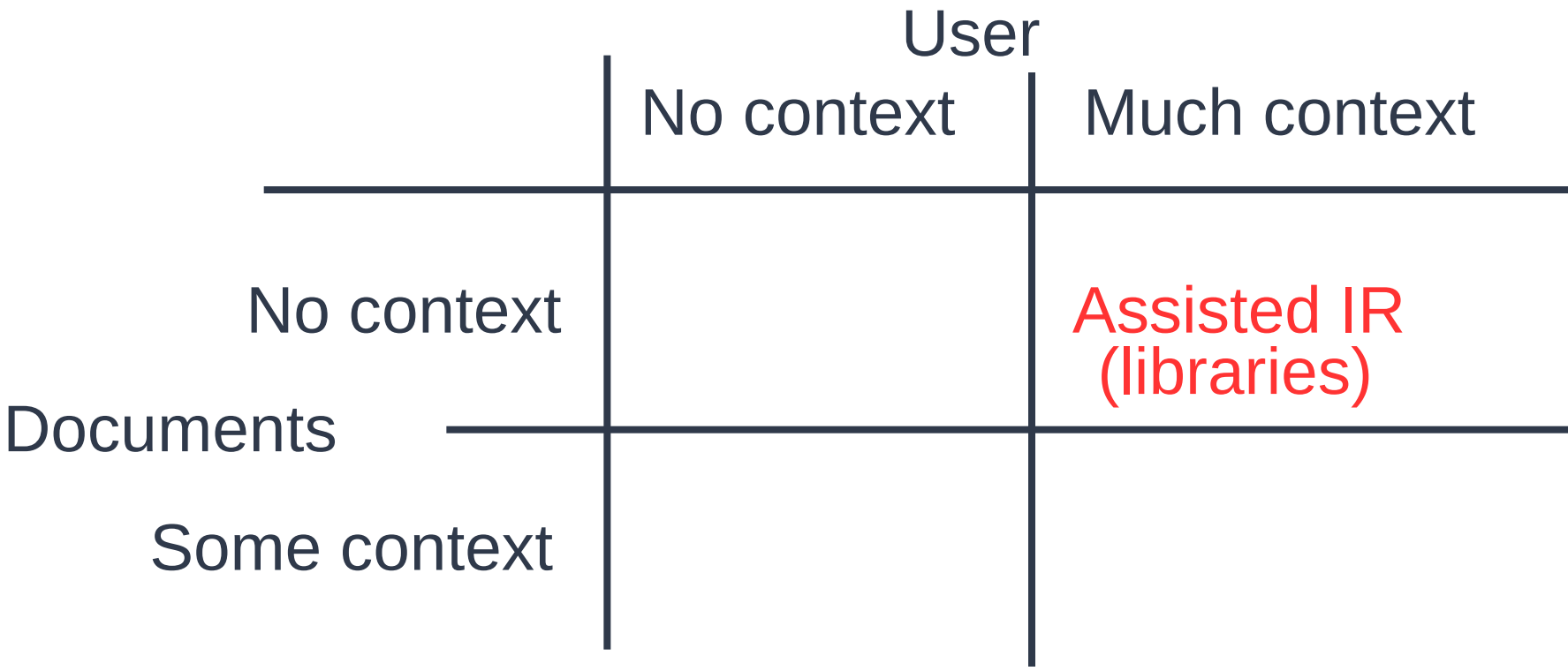
- Document context … we already do some of;



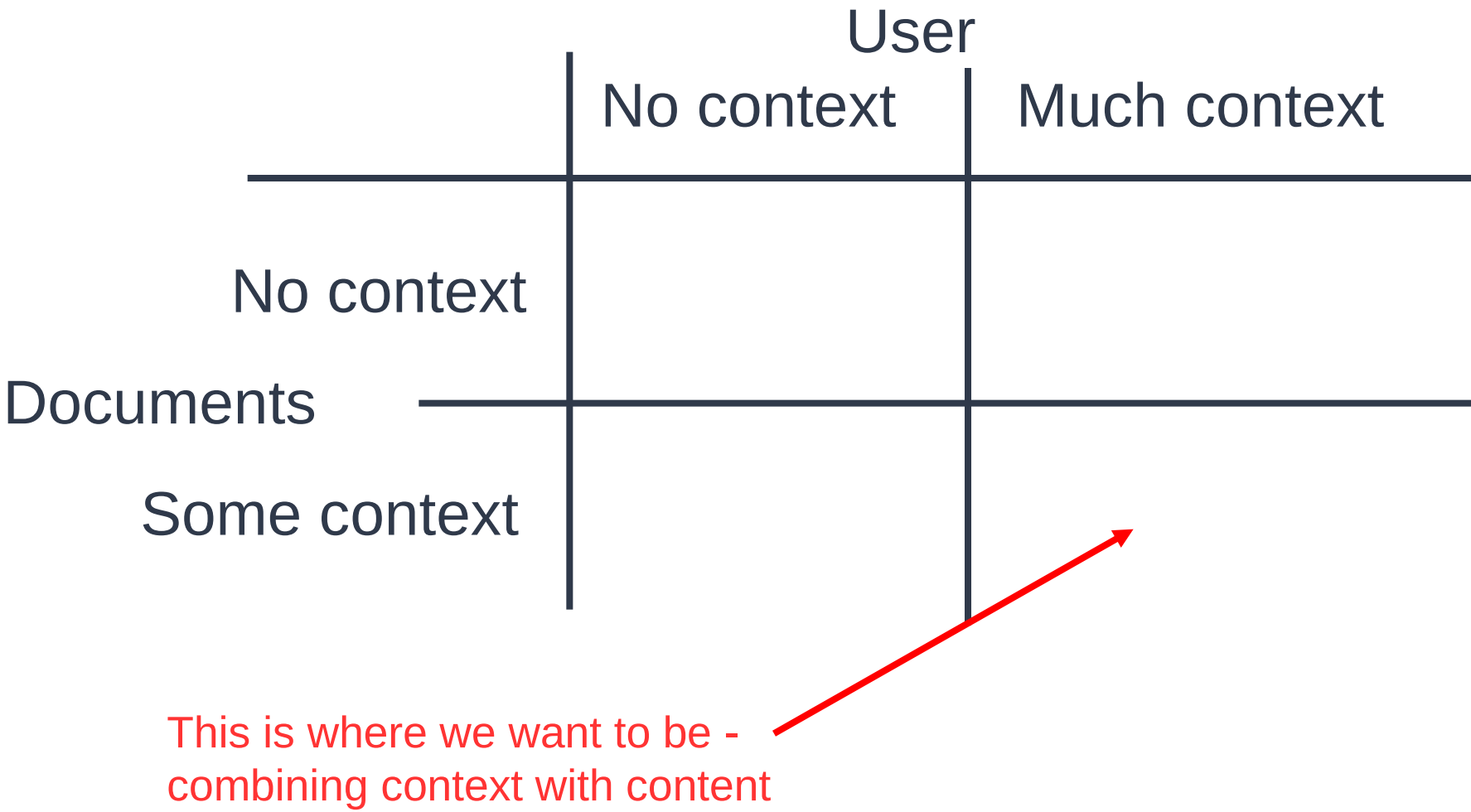
No knowledge of user, documents independent



No user context but document links, PageRanks, URL path lengths,



Information intermediaries learn the user and their needs and use information skills to navigate


User
No context
Much context
No context
Documents
Some context
This is where we want to be -
combining context with content

Context and Content: MediAssist

- As an example … personal photo management in MediAssist

MediAssist

Tools for organising, browsing and retrieving from a personal electronic picture collection

TOTAL #PHOTOS: 1722

LOCATION

Select the placed where the photos were taken. RESET

COUNTRY	STATE/COUNTY	CITY/TOWN
UNITED STATE:	Maryland	Any

TIME RANGE

Set start and end time for your search. ▶ CALENDAR

2001 2002 2003 2004 2005

SELECTION: 5 EVENTS 26 PHOTOS SHOW

◀ ADVANCED

SEARCH SUMMARY

Browse the events below and view more photos in each event. Click on a photo to see full-size. [INDIVIDUAL PHOTOS]

Photos:	26	INDOOR	22	WEATHER:	22	4	0	0	LIGHT STATUS: 0	9	0	17
Events:	5	OUTDOOR	4						

EVENT: Wellham Crossroads (historical), Maryland, UNITED STATES. (13-11-2004) 1 Photos - VIEW ALL

EVENT: District 9 (Gaithersburg) Election District, Maryland, UNITED STATES. (14-11-2004) 24 Photos - VIEW ALL

EVENT: District 9 (Gaithersburg) Election District, Maryland, UNITED STATES. (16-11-2004) 17 Photos - VIEW ALL

EVENT: Log Town (historical), Maryland, UNITED STATES. (17-11-2004) 26 Photos - VIEW ALL

Context and Content: MediAssist

- As an example … personal photo management in MediAssist
- Context:
  - Time (including time of day, day of week, etc)
  - Location
  - Light status, weather conditions
  - Indoor / outdoor
- Content:
  - Number & identity of people in photos
  - Buildings vs. natural environments

SenseCam

- A SenseCam is a small, wearable camera with sensors, developed by Microsoft Research, Cambridge UK:
  - Fisheye lens camera
  - Accelerometer XYZ
  - Light meter
  - PIR sensor
- It records sensor values and stores on-board for downloading;
- It generates potentially a million images per year;
- It is a lifelog recording device, part of the “recording the human digital memory” activity;

SenseCam

- We have no particular SenseCam application in mind except lifelogging, but others use it for
  - Assisting Alzheimer's suffers through memory augmentation;
  - Assisting healthcare professionals during their work;
  - Analysis of health and living patterns, personal health recordings;
  - Recording for personal education portfolios;
- We're applying content and context analysis to SenseCam image collections (0.5M);
- We consider a typical full-day of SenseCam images and develop underlying technology to support easy access;

- What does the data look like ?

Movie playback ?

- Watching fast movie playback of image sequences is not an ideal interaction:
  - Intensive concentration required during playback
  - There is no structure to the day, event boundaries cannot be seen
  - Sense of time is skewed
    - More images of unimportant, regularly occurring events;
    - Fewer images of important irregular events;
- Need to redress this by structuring into events, and assigning event importance

Structuring SenseCam Images

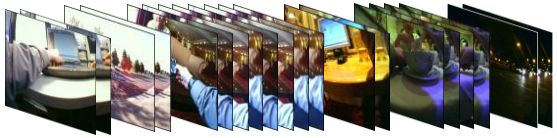
A day's SenseCam images (3,000 – 4,000)

Event Segmentation

Multiple Events

Finishing work in the lab | **At the bus stop** | **Chatting at Skylon Hotel lobby** | **Moving to a room** | **Tea time** | **On the way back home**

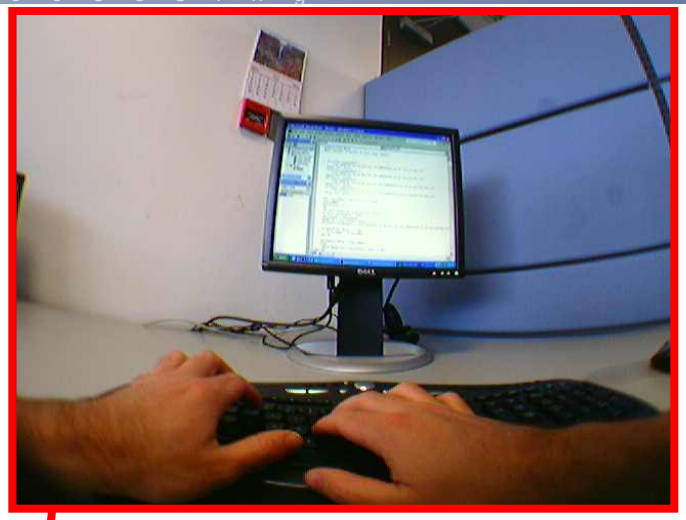
Summarisation



Automatic Event Segmentation

- Task: automatically determine events from a collection of SenseCam image data;
- Approach based around image-image similarity □□using LL MPEG-7 features where differences may indicate events, coupled with sensor readings where changes may indicate events

Image Similarity Calculation



Extract MPEG-7 descriptors for this image

- Scalable Colour
- Colour Structure
- Colour Layout
- Colour Moments
- Edge Histogram
- Homogeneous Texture

:

- Sensor readings

Extract MPEG-7 descriptors for this image

- Scalable Colour
- Colour Structure
- Colour Layout
- Colour Moments
- Edge Histogram
- Homogeneous Texture

:

- Sensor readings

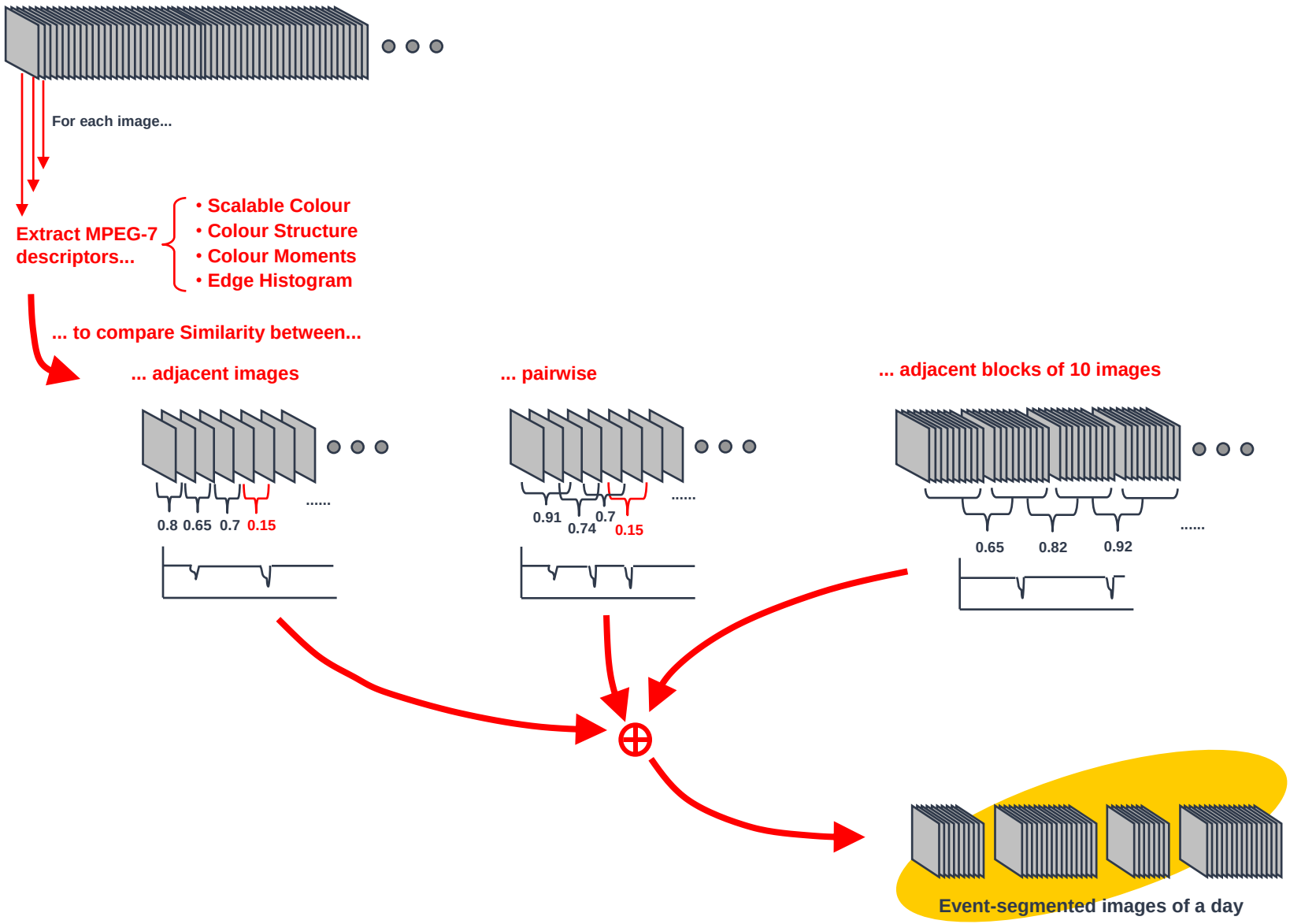
Similarity Score

Automatic Event Segmentation

- Task: automatically determine events from a collection of SenseCam image data;
- Approach based around image-image similarity □□using LL MPEG-7 features where differences may indicate events, coupled with sensor readings where changes may indicate events;
- Similar problem to shot bound detection in video but more challenging … fish-eye lens … lesser image similarities within events;

- We take several approaches;

Event Segmentation I



Event Segmentation II

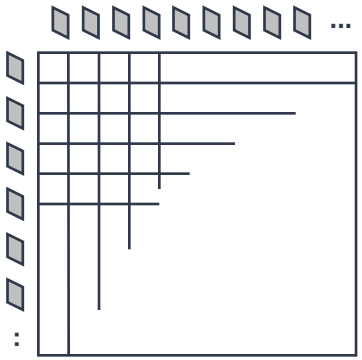
- Use similarity clustering, and time
  - Combine low-level content analysis and context information (i.e. metadata provided by the SenseCam and temporal data)
  - Generate a similarity matrix by fusing low-level and metadata information
  - Implement time constraints to constrain clustering
  - Simple hierarchical clustering of images into events

Event Segmentation II

Extract MPEG-7 descriptors
- Scalable Colour
- Colour Layout
- Edge Histogram
- Homogeneous Texture

\+ GPS meta-data ...
- Light
- Temperature
- Accelerometer

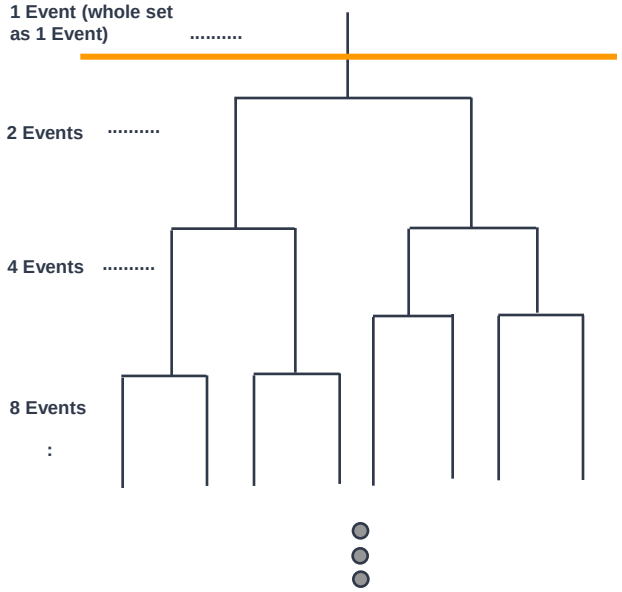
... to calculate Similarity among images

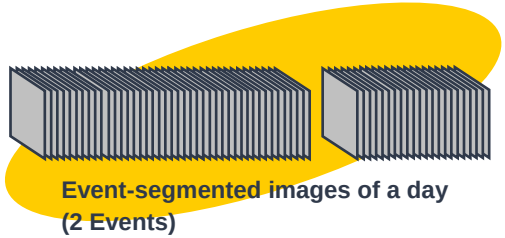


Similarity matrix

Then apply Temporal constraints...

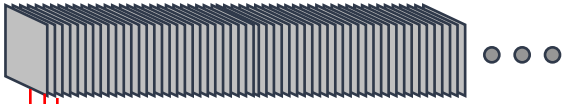
... to vary the number of Events





Event-segmented images of a day (2 Events)

Event Segmentation II

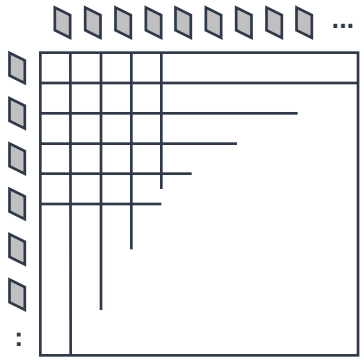


For each image...

Extract MPEG-7 descriptors
- Scalable Colour
- Colour Layout
- Edge Histogram
- Homogeneous Texture

\+ GPS meta-data ...
- Light
- Temperature
- Accelerometer

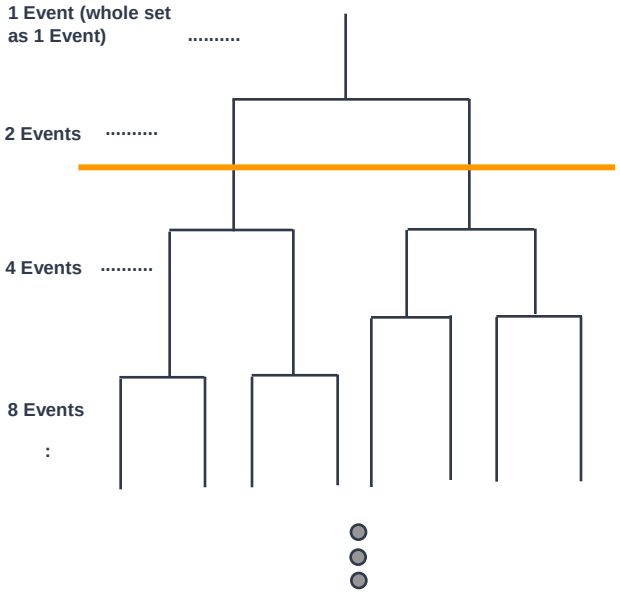
... to calculate Similarity among images

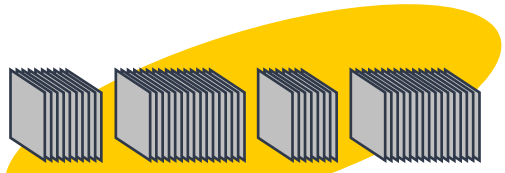


Similarity matrix

Then apply Temporal constraints...

... to variate the number of Events





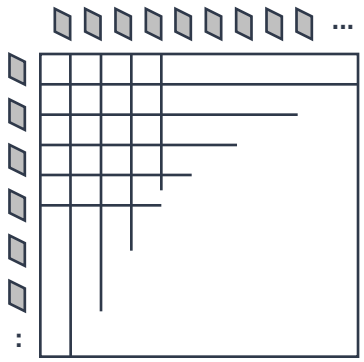
Event-segmented images of a day (4 Events)

Event Segmentation II

Extract MPEG-7 descriptors
- Scalable Colour
- Colour Layout
- Edge Histogram
- Homogeneous Texture

\+ GPS meta-data ...
- Light
- Temperature
- Accelerometer

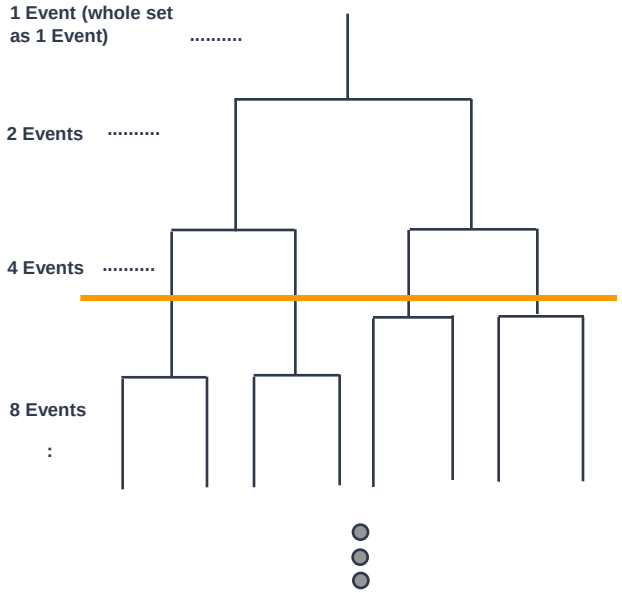
... to calculate Similarity among images

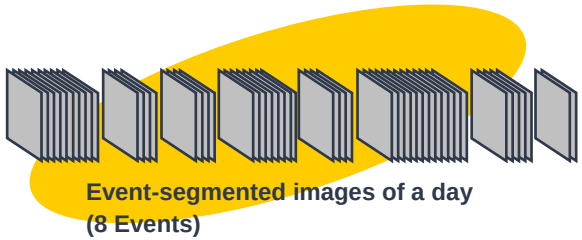


Similarity matrix

Then apply Temporal constraints...

... to variate the number of Events





Event-segmented images of a day (8 Events)

Event Grouping III

- Classify images into 1 of three categories



1. Static Person
   - Person performing some activity
   - a.g. at computer, meeting, eating etc.




2. Moving Person
   - Travelling between locations

3. Static Camera
   - Sense Cam is put down
   - User is not wearing it

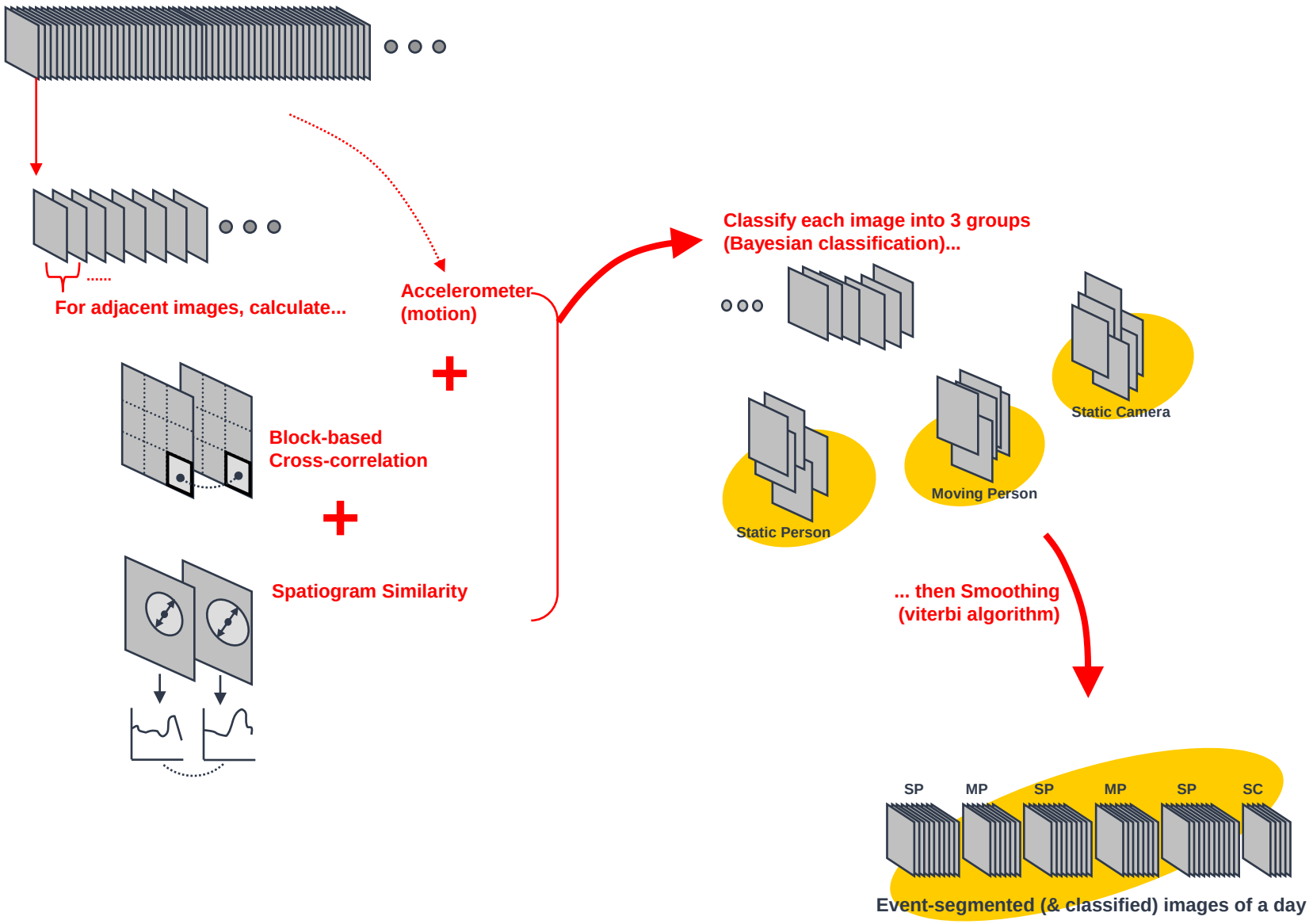


Features Used

1. Block-based cross-correlation across images
2. Spatiogram image colour similarity
3. Accelerometer motion

- Feature-based training
- Bayesian approach to classification
- Viterbi algorithm used to smooth results

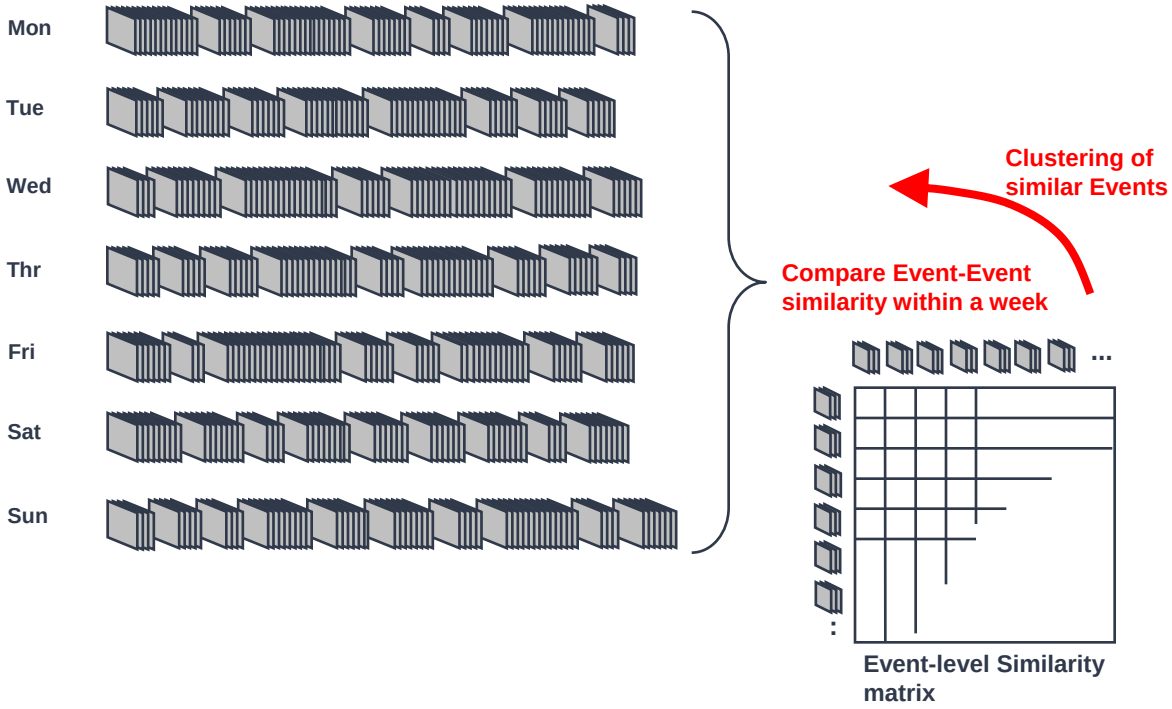
Event Segmentation III

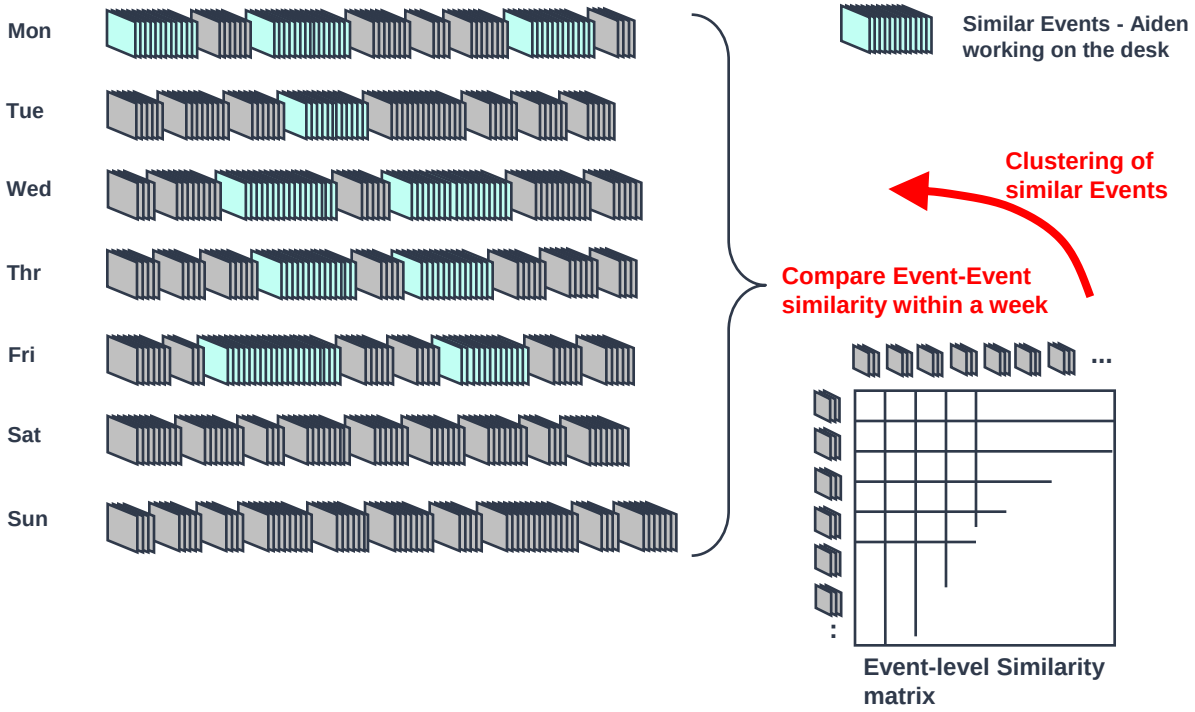


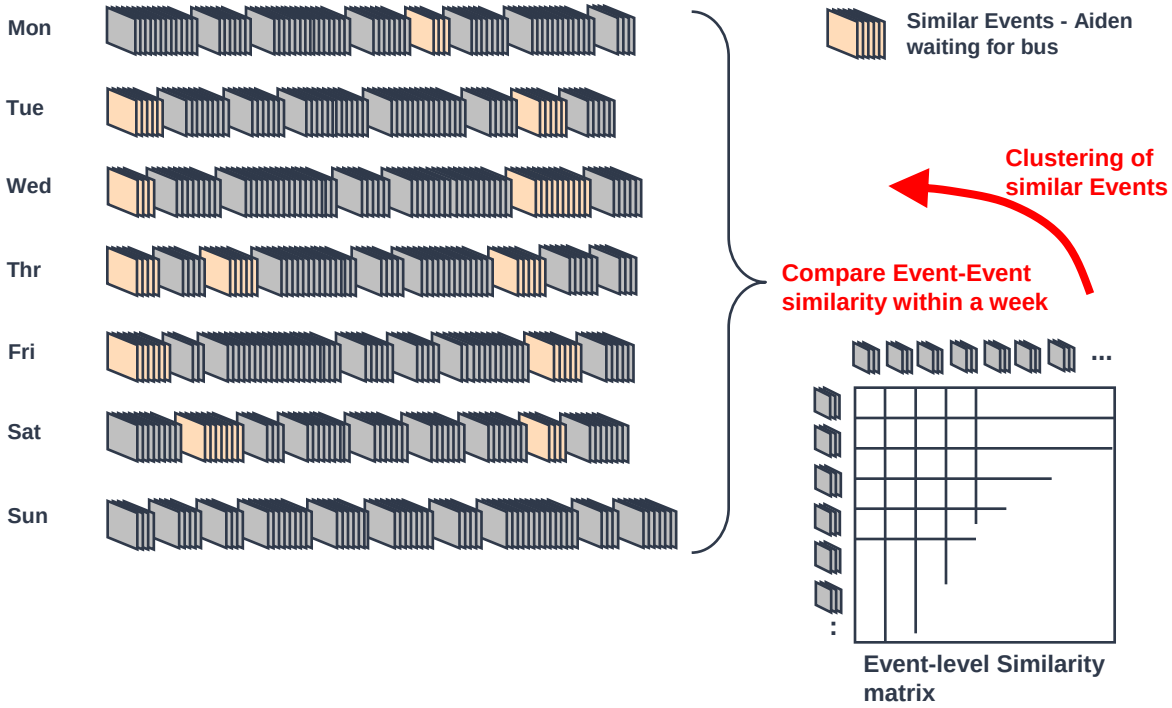
Generating Event Importances

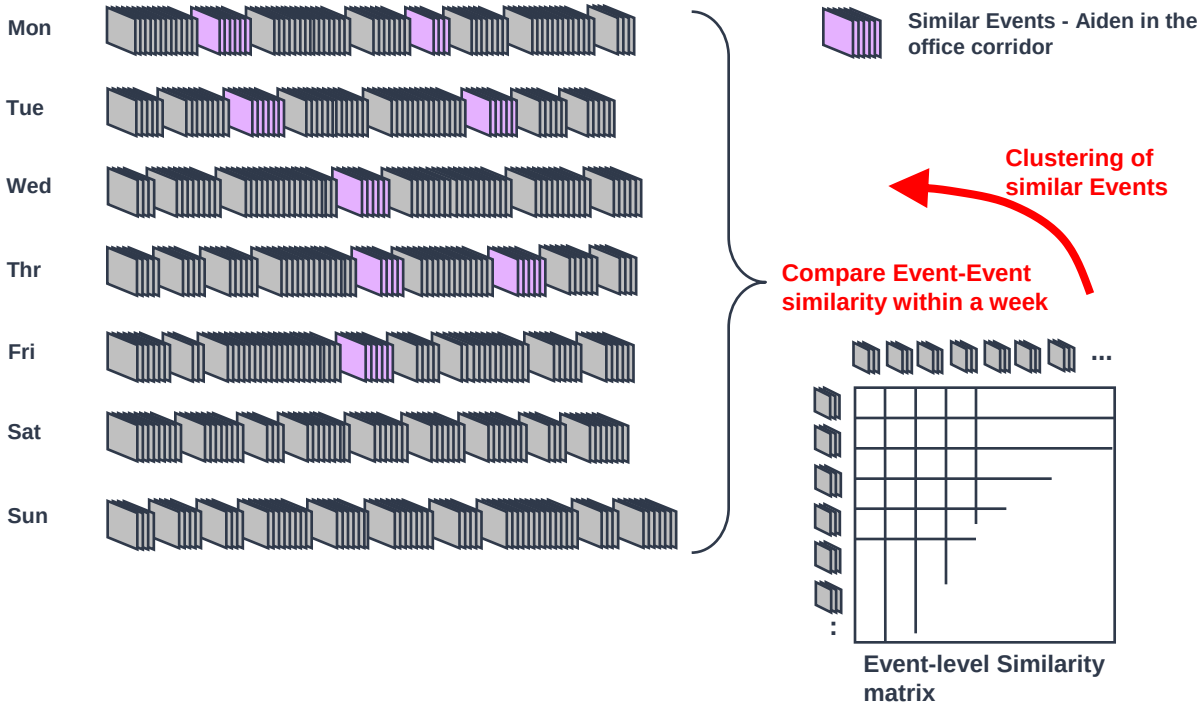
- Assume events already segmented□;
- Calculate average value for events using low level features from all images;
- Generate event-event similarity matrix using the average values from each event;

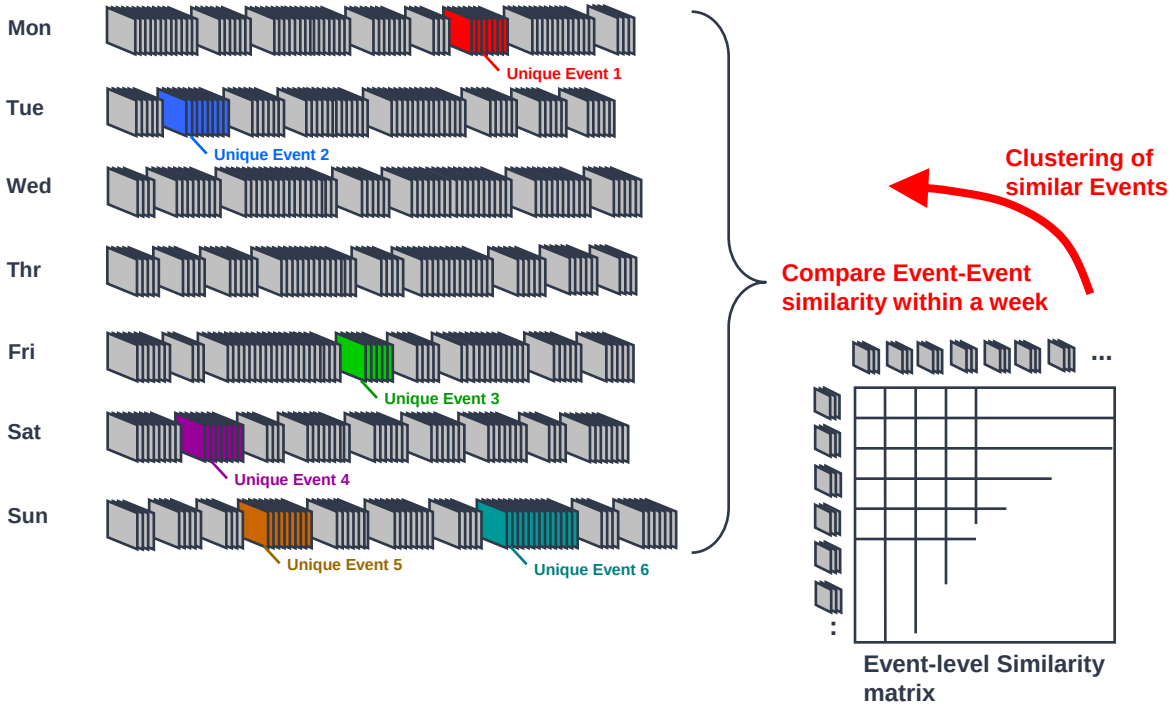
- Visually similar events can then be detected, and used to determine event importance / novelty / uniqueness;

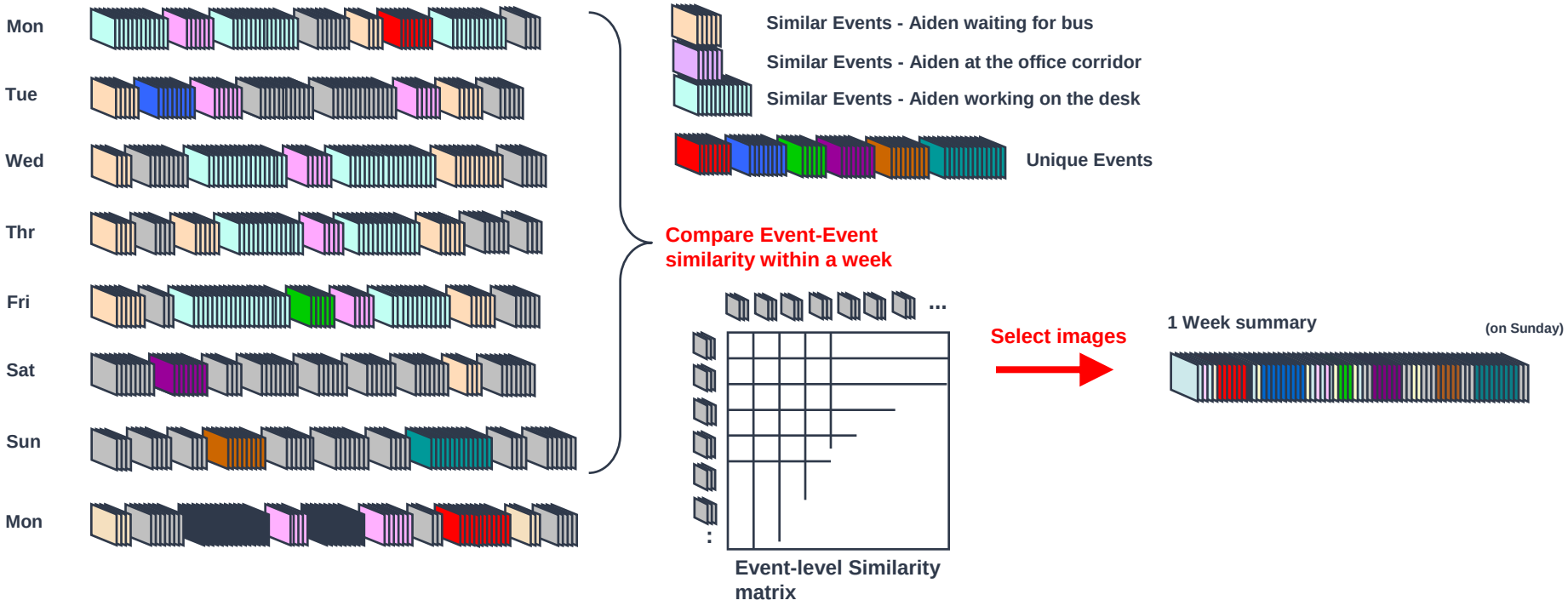

Mon
Tue
Wed
Thr
Fri
Sat
Sun
Clustering of similar Events
Compare Event-Event similarity within a week
...
Event-level Similarity matrix


Mon
Tue
Wed
Thr
Fri
Sat
Sun
Similar Events - Aiden working on the desk
Clustering of similar Events
Compare Event-Event similarity within a week
...
Event-level Similarity matrix

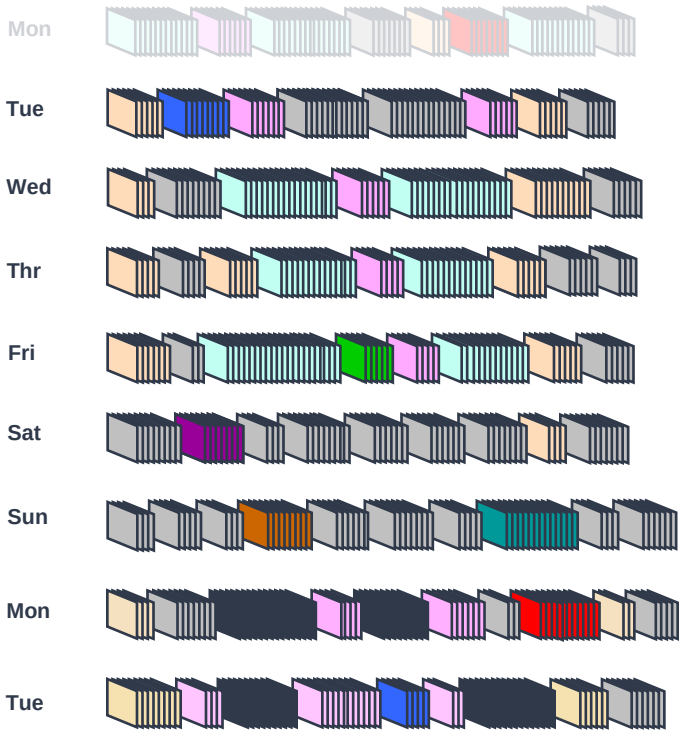

Mon
Tue
Wed
Thr
Fri
Sat
Sun
Similar Events - Aiden waiting for bus
Clustering of similar Events
Compare Event-Event similarity within a week
...
Event-level Similarity matrix

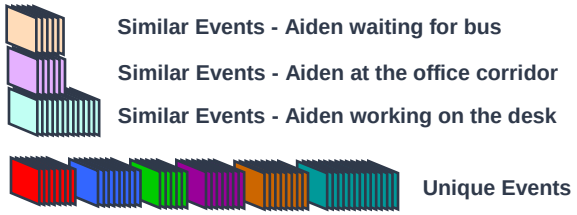

Mon
Tue
Wed
Thr
Fri
Sat
Sun
Similar Events - Aiden in the office corridor
Clustering of similar Events
Compare Event-Event similarity within a week
...
Event-level Similarity matrix


Mon
Unique Event 1
Tue
Unique Event 2
Wed
Thr
Fri
Unique Event 3
Sat
Unique Event 4
Sun
Unique Event 5
Unique Event 6
Clustering of similar Events
Compare Event-Event similarity within a week
...
Event-level Similarity matrix

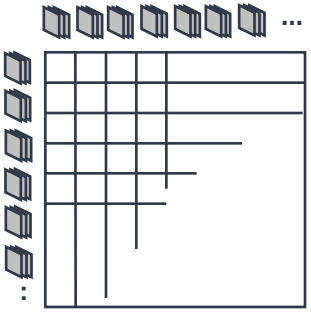


Perhaps generate a rolling movie of the last 7 days … inspired by Addenbrooke's hospital application;





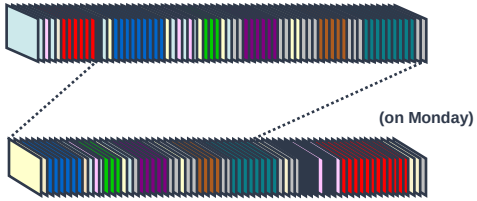
Compare Event-Event similarity within a week

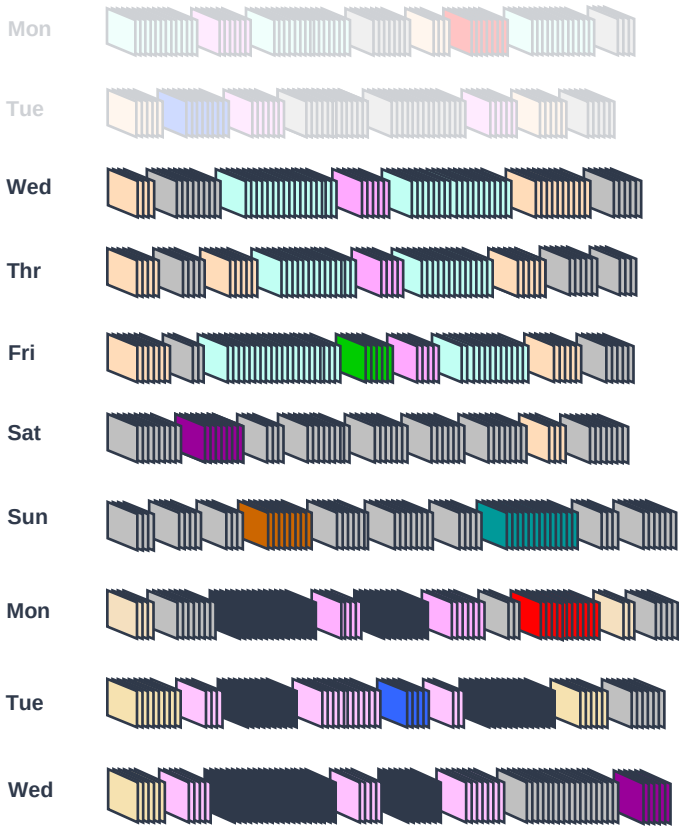


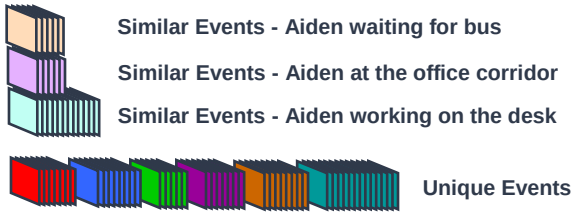
Event-level Similarity matrix

Select images

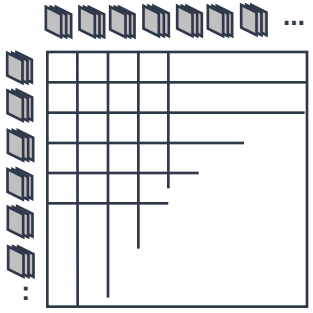
Select images







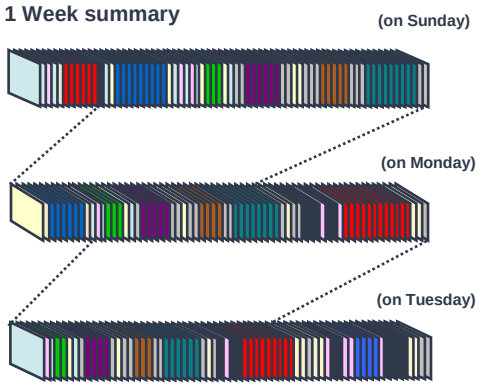
Compare Event-Event similarity within a week

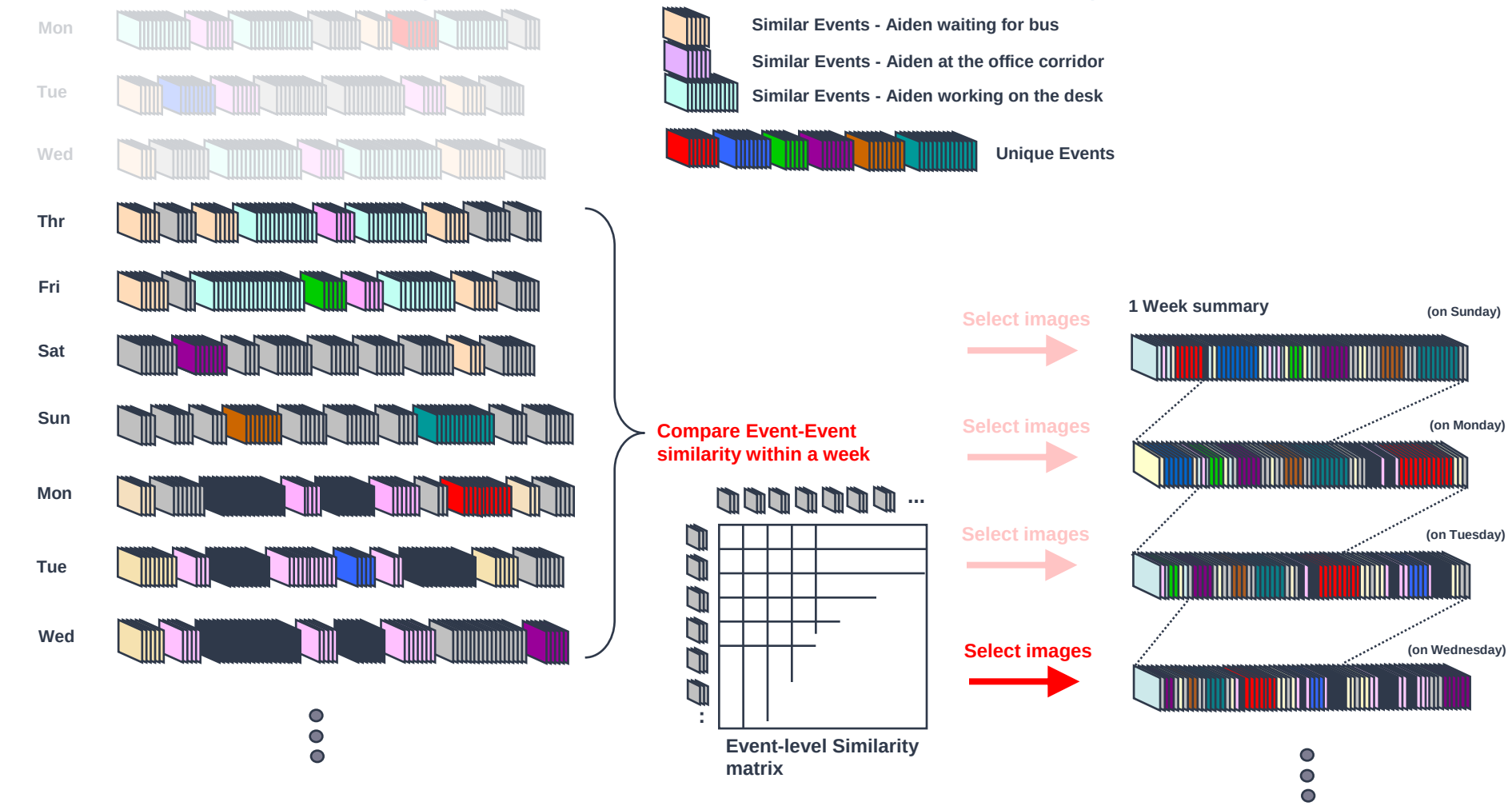


Select images

Select images

Select images

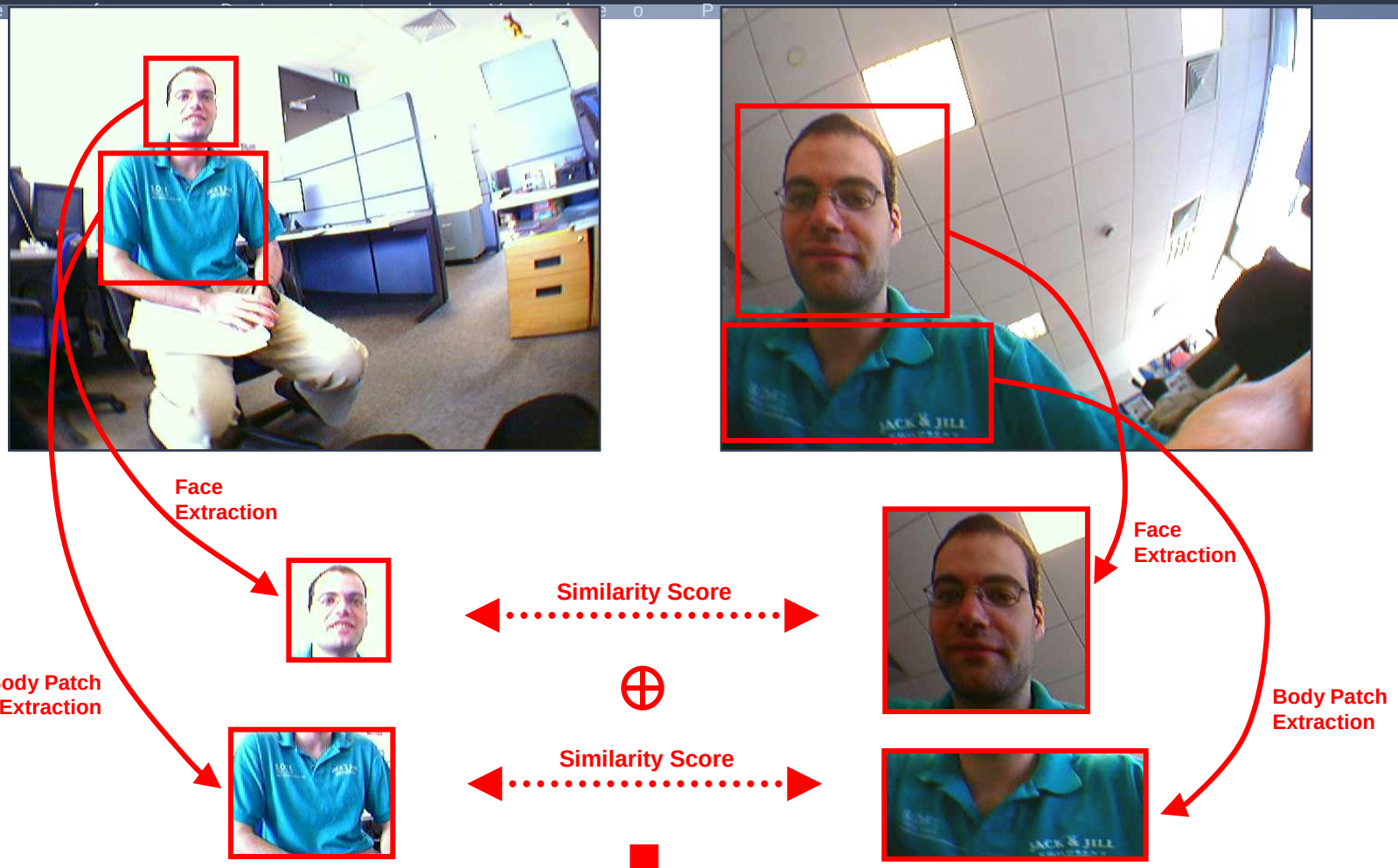



Mon
Tue
Wed
Thr
Fri
Sat
Sun
Mon
Tue
Wed
Similar Events - Aiden waiting for bus
Similar Events - Aiden at the office corridor
Similar Events - Aiden working on the desk
Unique Events
Compare Event-Event similarity within a week
Event-level Similarity matrix
Select images
Select images
Select images
Select images
1 Week summary
(on Sunday)
(on Monday)
(on Tuesday)
(on Wednesday)

Other image structuring …

- We're trying other things …
- Apply face detection software to detection the presence of a face in the SenseCam image;
- On its own it is poor, so use body patch matching
  - Locate body patch under face occurrences;
  - Identify similar body patches by color to detect subsequent appearances within an event;
- Combine face and body patch

- Works well for personal photos, but SenseCam images are lower quality;


Face
Extraction
Face
Extraction
Similarity Score
Body Patch
Extraction
Body Patch
Extraction
Similarity Score
Combined
Similarity Score

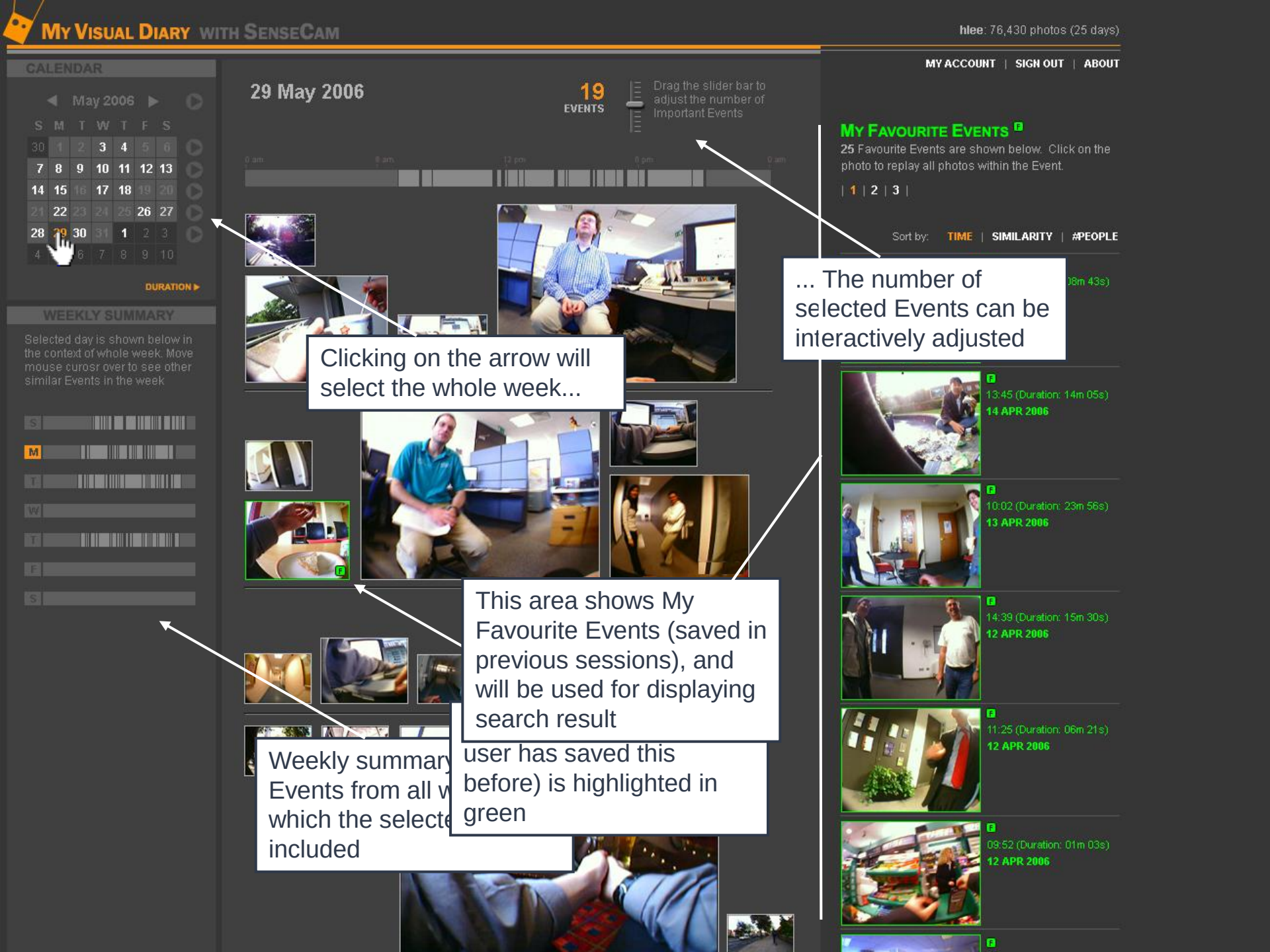
Combining Multi-Sensor Data …

- To determine whether "events" can be identified based on multiple sensors, multiple evidence sources
- External context data collected from:
  - GPS Device
  - BodyMedia Device
  - Heart Rate Monitor
  - SenseCam
  - Audio recording of the day
- Internal content analysis using 39 (TRECVid) features and MediaMill-101 features

- Lots more things to try … and then …

Want to turn sequential movie-like playback into an interactive, spatial browsing interaction.

With the following interface:


MY VISUAL DIARY WITH SENSECAM
hlee: 76,430 photos (25 days)
MY ACCOUNT | SIGN OUT | ABOUT
CALENDAR
May 2006
DURATION
WEEKLY SUMMARY
Selected day is shown below in the context of whole week. Move mouse curosr over to see other similar Events in the week
29 May 2006
19 EVENTS
Drag the slider bar to adjust the number of Important Events
MY FAVOURITE EVENTS
25 Favourite Events are shown below. Click on the photo to replay all photos within the Event.
| 1 | 2 | 3 |
Sort by: TIME | SIMILARITY | #PEOPLE
13:45 (Duration: 14m 05s)
14 APR 2006
10:02 (Duration: 23m 56s)
13 APR 2006
14:39 (Duration: 15m 30s)
12 APR 2006
11:25 (Duration: 06m 21s)
12 APR 2006
09:52 (Duration: 01m 03s)
12 APR 2006
Clicking on the arrow will select the whole week...
... The number of selected Events can be interactively adjusted
This area shows My Favourite Events (saved in previous sessions), and will be used for displaying search result
user has saved this before) is highlighted in green
Weekly summary
Events from all w
which the selecte
included

My Visual Diary with SenseCam

hlee: 76,430 photos (25 days)

MY ACCOUNT | SIGN OUT | ABOUT

CALENDAR

May 2006

S	M	T	W	T	F	S
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	6	7	8	9	10

DURATION ▶

WEEKLY SUMMARY

Selected day is shown below in the context of whole week. Move mouse curosr over to see other similar Events in the week

S
M
T
W
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F
S

29 May 2006

19 EVENTS

Drag the slider bar to adjust the number of Important Events

0 am 6 am 12 pm 6 pm 0 am

MY FAVOURITE EVENTS

25 Favourite Events are shown below. Click on the photo to replay all photos within the Event.

| 1 | 2 | 3 |

Sort by: TIME | SIMILARITY | #PEOPLE

16:20 (Duration: 08m 43s)
14 APR 2006

13:45 (Duration: 14m 05s)
14 APR 2006

10:02 (Duration: 23m 56s)
13 APR 2006

14:39 (Duration: 15m 30s)
12 APR 2006

11:25 (Duration: 06m 21s)
12 APR 2006

09:52 (Duration: 01m 03s)
12 APR 2006

MY VISUAL DIARY WITH SENSECAM

hlee: 76,430 photos (25 days)

MY ACCOUNT | SIGN OUT | ABOUT

CALENDAR

May 2006

S	M	T	W	T	F	S
30	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
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To see the visual diary between two dates, specify the start and end dates then click the arrow.

FROM: 29 May 2006

TO: 29 May 2006

◂CALENDAR

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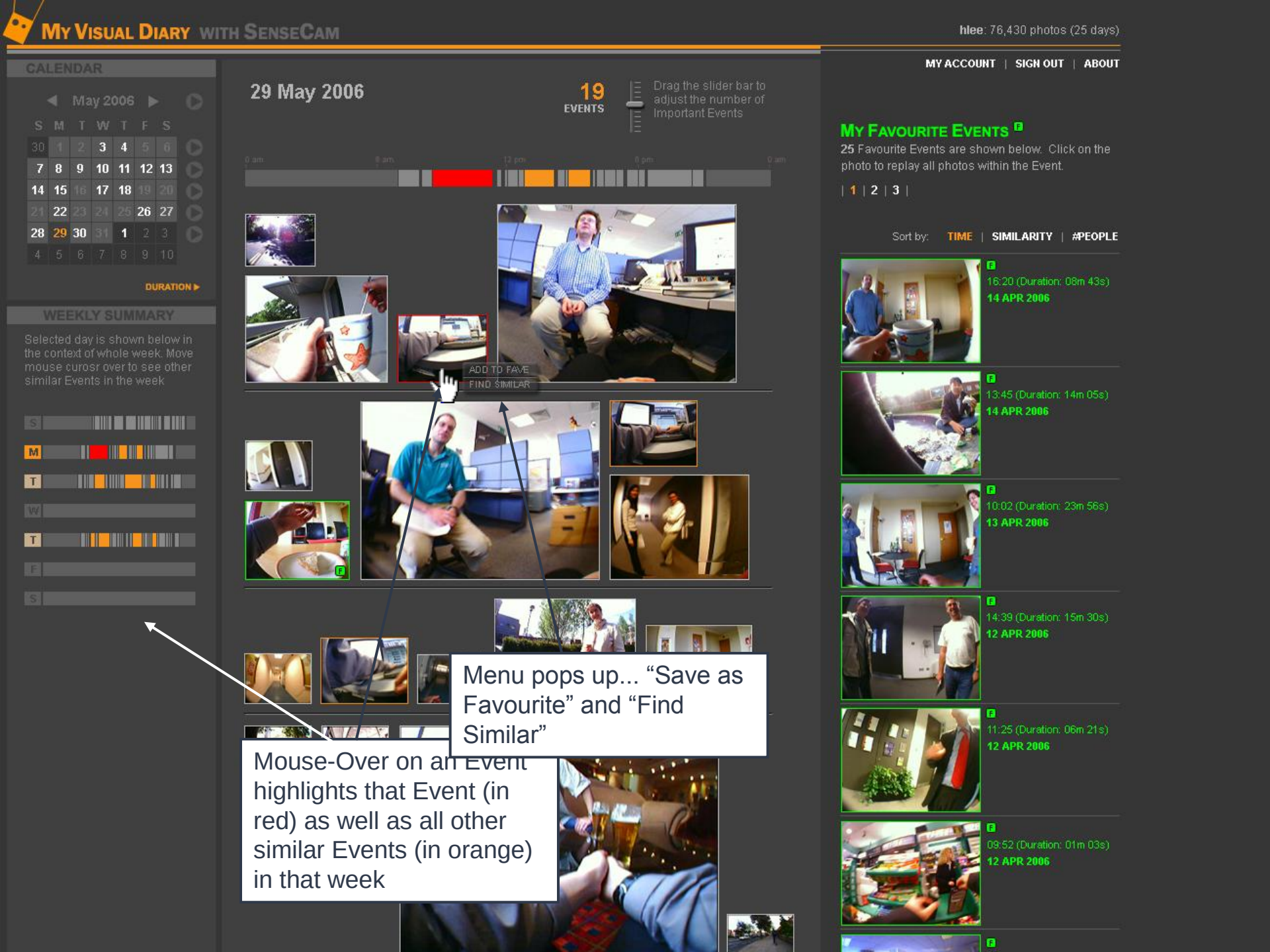
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MY ACCOUNT | SIGN OUT | ABOUT
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S M T W T F S
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29 May 2006
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ADD TO FAVE
FIND SIMILAR
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12 APR 2006
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Menu pops up... “Save as Favourite” and “Find Similar”
Mouse-Over on an Event highlights that Event (in red) as well as all other similar Events (in orange) in that week

MY VISUAL DIARY WITH SENSECAM

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MY ACCOUNT | SIGN OUT | ABOUT

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F FAVOURITE (25)

SIMILAR EVENTS

92 Similar Events have been found. Click on the photo to replay all photos within the Event.

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15:19 (Duration: 21m 10s)

Conclusions

- Status … everything is built, data gathered, we're processing events and putting it all together now;

- SenseCam analysis is sophisticated, application stretches capabilities of image processing in order to determine semantics for SenseCam archives;
- Yet every step is either context or content … and we have to stop and think which it is !
- Takehome message … in most Multimedia Semantic applications (e.g. MediAssist, SenseCam) we seamlessly use context and content … they have now fused into one;