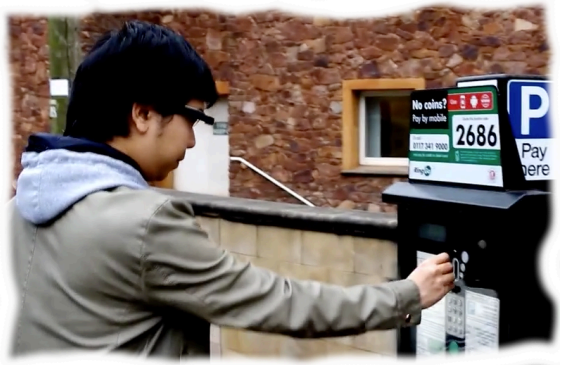
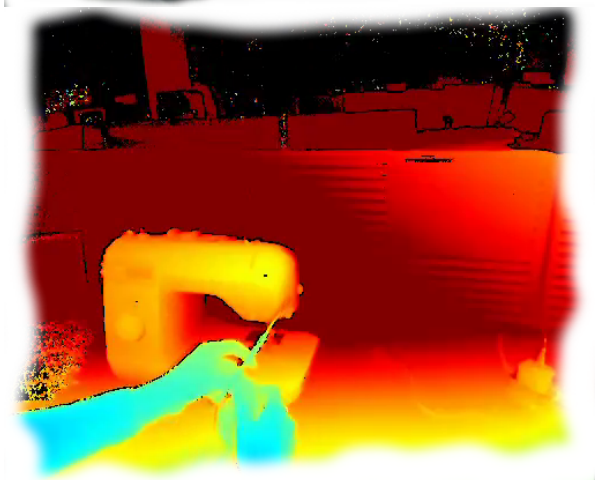




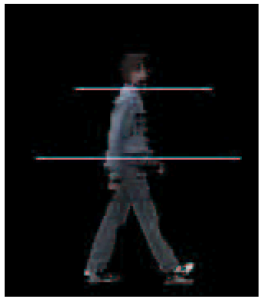
Egocentric Vision

Dr Dima Damen

Department of Computer Science

Short Bio

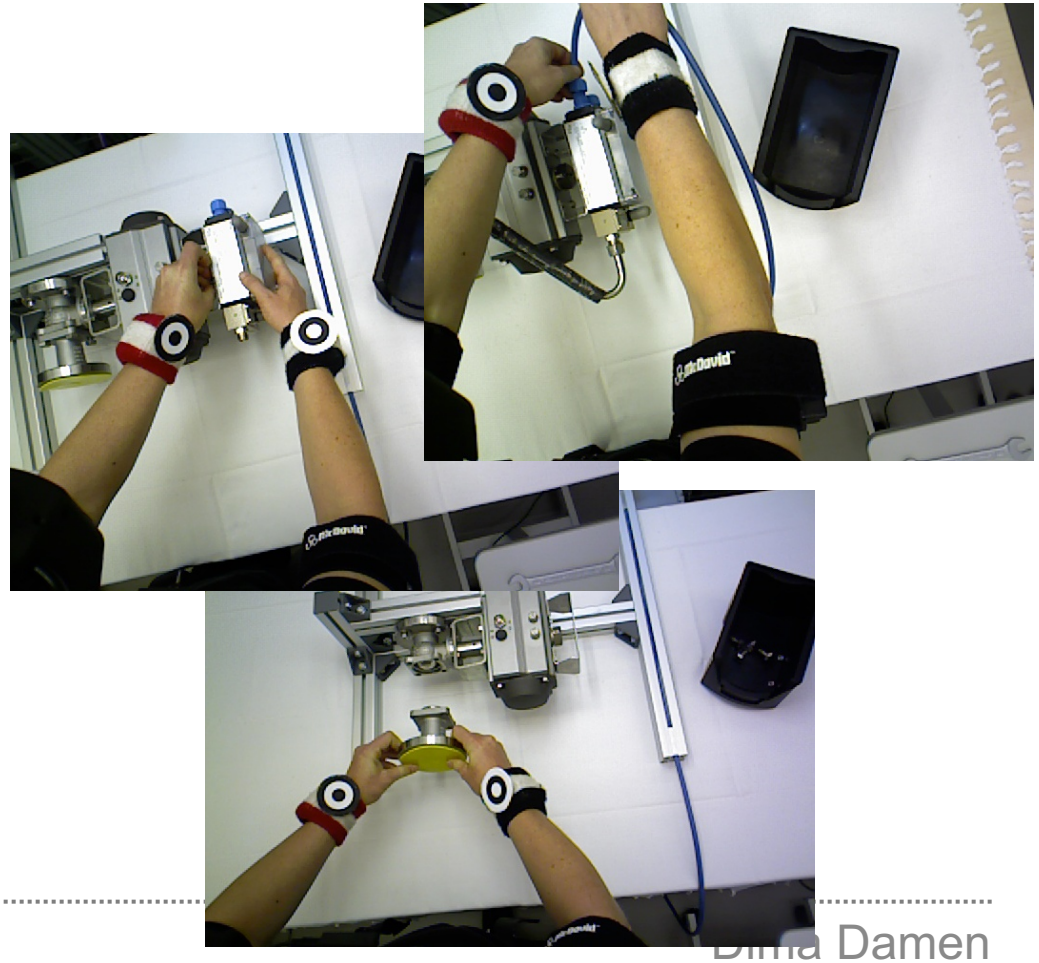
- 1998-2002 BSC in Computer Science
- 2002-2003 MSc in Distributed Multimedia Sys.


- 2006-2009 PhD in Computer Vision


Short Bio

- 2010-2012 Postdoc on EU-FP7 project



Short Bio

- 2013- Assistant Prof in Computer Vision

Egocentric Vision?

- Research interests: action and activity recognition
- Particularly centred around the viewpoint or the perspective

Ego…

Ego… a person's sense of self-esteem or self-importance

Egocentric vision… the wearer serves as the central reference point in the study of interesting entities: objects, actions, interactions and intentions

Ego…

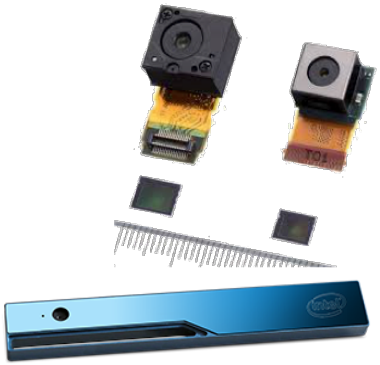
Visual Sensing – the landscape

Visual Sensing – the landscape

Visual Sensing – the landscape

Visual Sensing – the landscape





Most Wearable!

Hand-Held Wireless

Hand-Held Wired

Least Static

Wearable

Wearable?

Wearable?

Wearable?

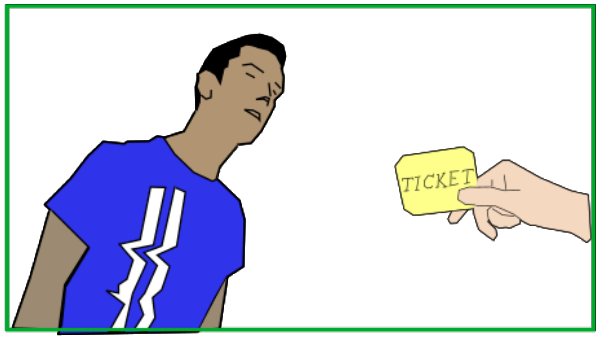
Wearable?

Wearable?

- Hat-Mounted
- Head-Mounted
- Glass-Mounted
- Shoulder-Mounted
- Chest-Mounted
- Wrist-Mounted
- Belt-Mounted
- Ankle-Mounted

But why do we care about… hardware???

- OPV (Ordinal-Person Views)
  - FPV (First-Person View)
  - SPV (Second-Person View)
  - TPV (Third-Person View)



See for yourself!

- Videos...

Top-Left: Fathi – Disney dataset for social interactions 2012
Top-Right Damen EPIC-Kitchen 2017
Bottom-Left Damen BEOID 2014
Bottom-Right Kitani (Youtube) Sports 2011

Conclusions?

- Just another camera?
- Just a shaking camera?

Egocentric Vision

- The Unique Problems
  1. Camera Motion
  2. Mapping and Localisation (ref tomorrow's talk)
  3. Attention and Task-Relevance
  4. Object Interactions
  5. Multi-view Solutions
- The Unique Applications
  1. Video Summarisation
  2. Skill Determination
  3. Real-time solutions

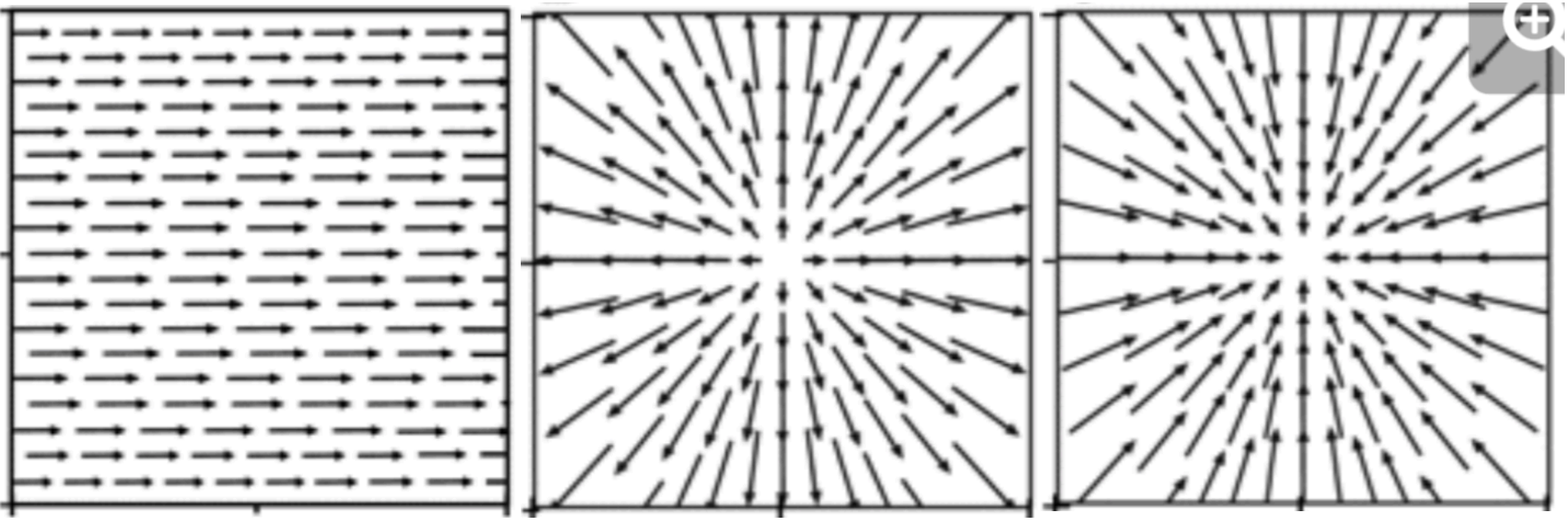
The Unique Problems

1. Camera Motion

1. Camera Motion

- Two types of motion
  - Egomotion
  - Foreground motion

Ego-motion



rotating **approaching** **receding**

Ego-motion

- Detect to:
  - Use?
  - Remove?

Hyperlapse

- https://youtu.be/sA4Za3Hv6ng

The Unique Problems

3. Attention and Task Relevance

Attention and Task Relevance

- What is attention?
  - Non-Egocentric Attention Models (→ Saliency)

DUT-OMRON dataset
http://saliencydetection.net/dut-omron

Attention and Task Relevance

- What is attention?
  - Non-Egocentric Attention Models (→ Saliency)

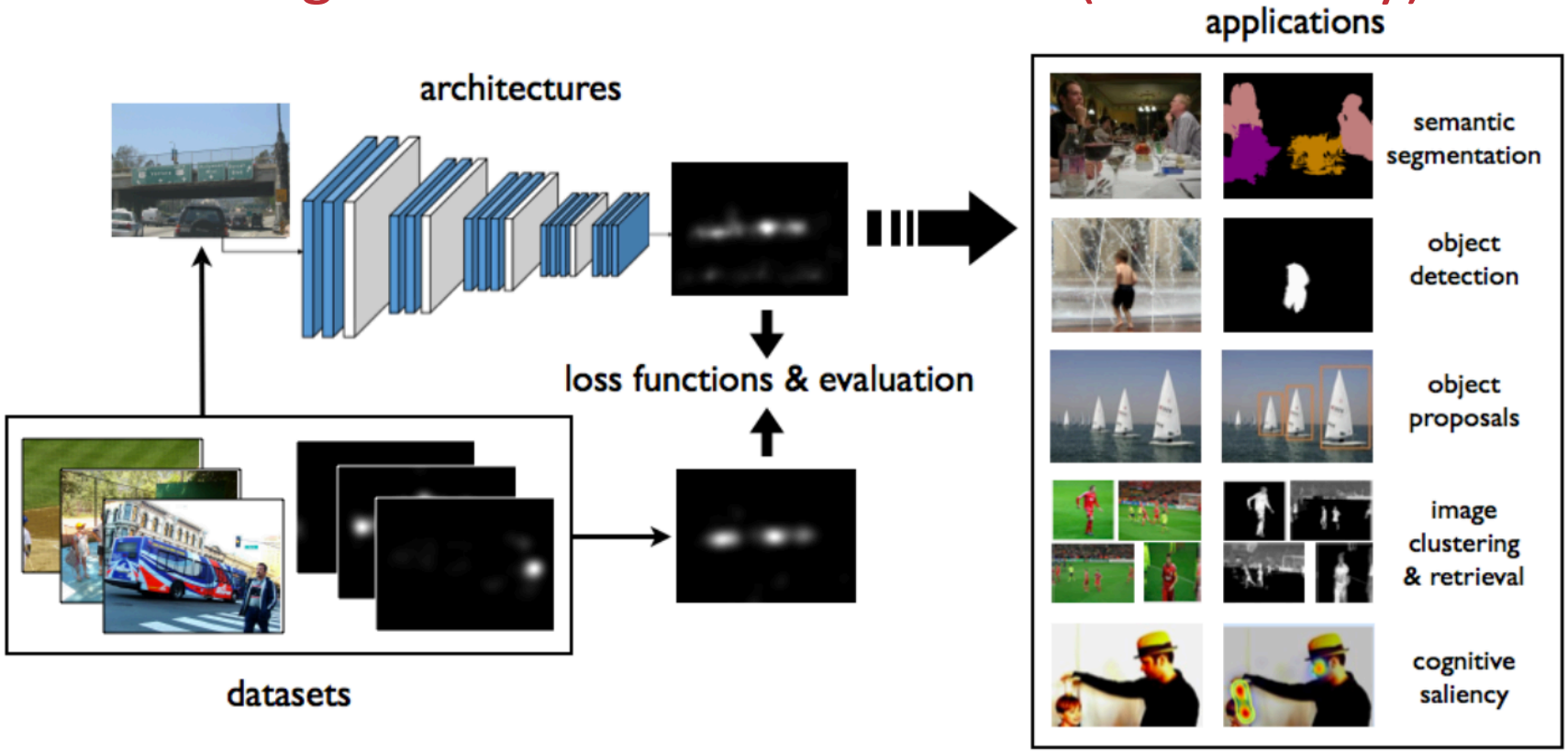


Figure: Zoya Bylinskii & Tilke Judd, ECCV 2016 Tutorial
http://saliency.mit.edu/ECCVTutorial/newDirectionsInSaliency.pdf

Attention and Task Relevance

Attention and Task Relevance

- Attention in egocentric vision
  - Foreground segmentation
  - Hand-region segmentation
  - Gaze tracking

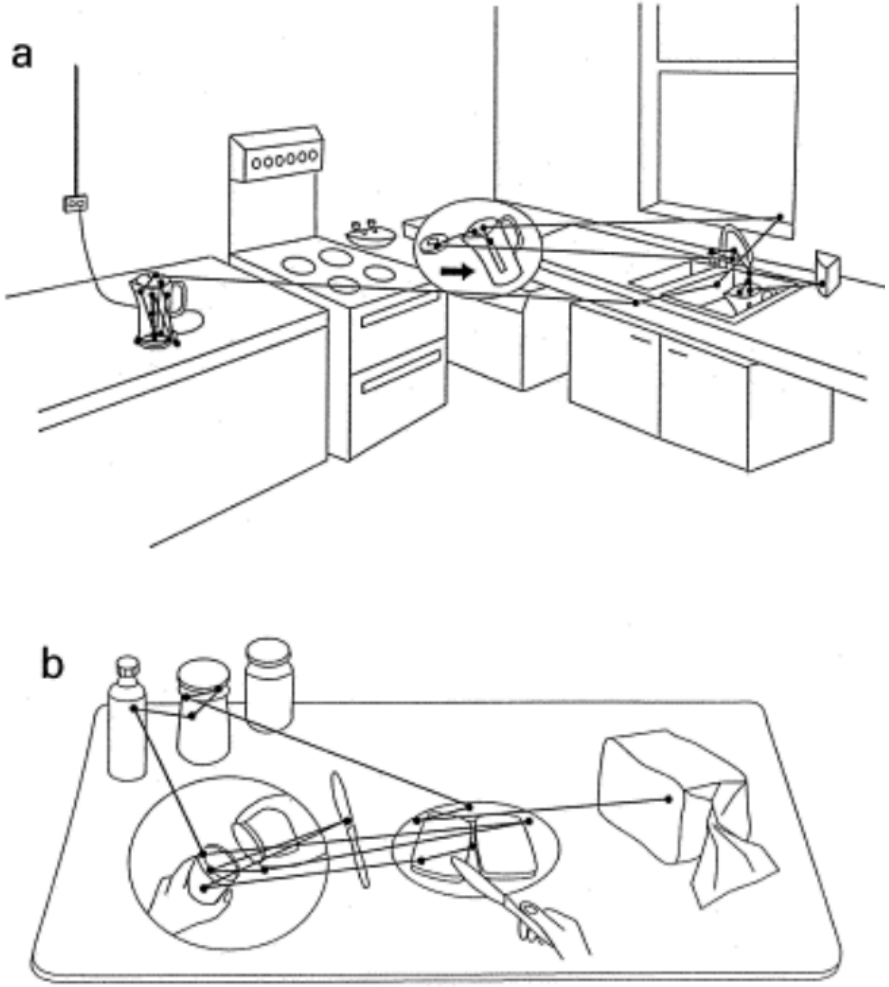
Quick introduction to human gaze

- Humans iterate between “fixations” and “saccades”
  - Fixation: short stops
  - Saccade: quick movements between fixations
- https://youtu.be/pknohrsz4Qs

Quick introduction to human gaze

Quick introduction to human gaze

Quick introduction to human gaze



Land and Hayhoe (2001) In what ways do eye movements contribute to everyday activities? Vision Research

Quick introduction to human gaze

- The notion of fixation/saccade has recently inspired attention models in vision

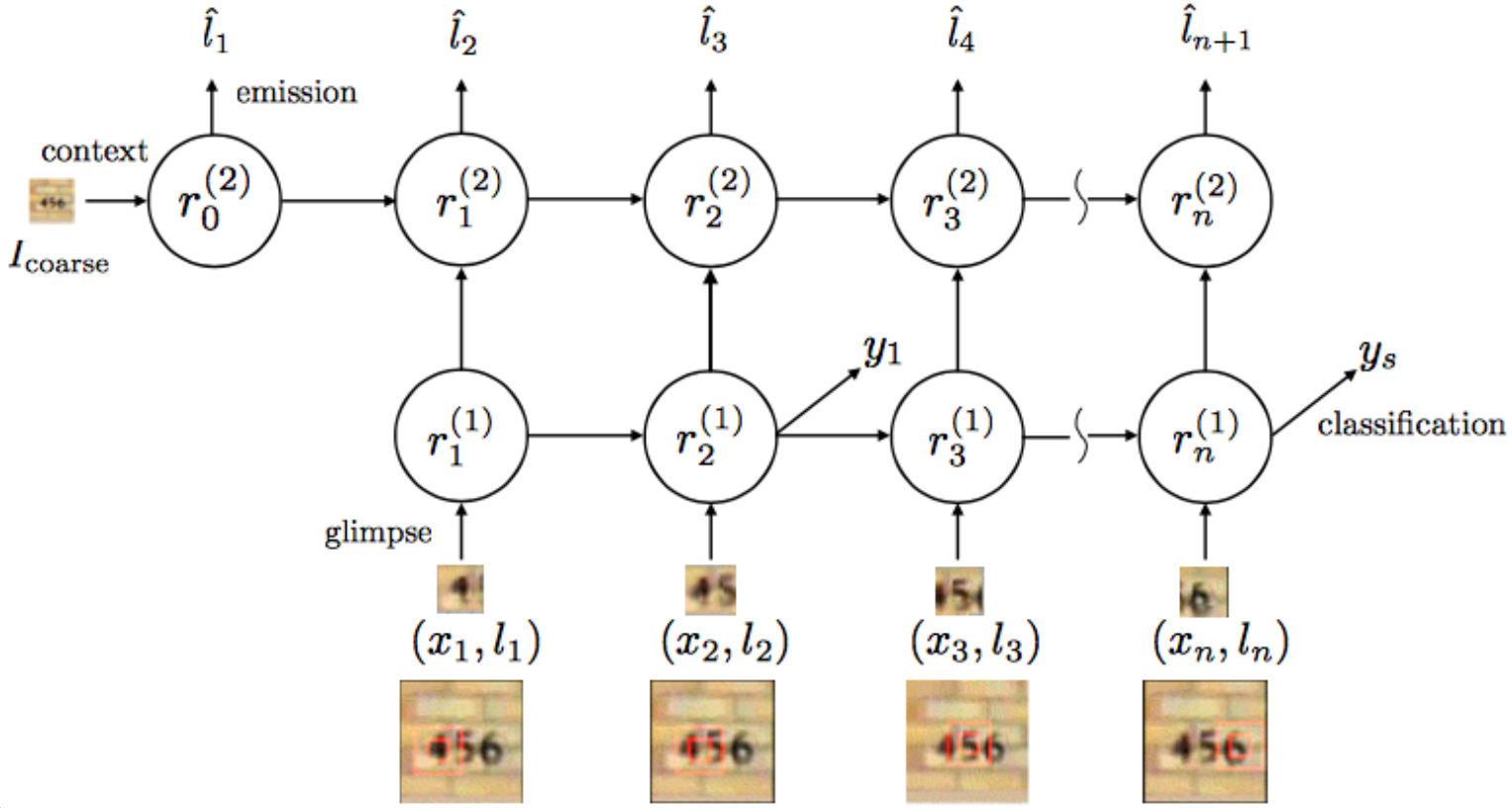


Figure: Lei Ba et al (2015). Multiple Object Recognition with Visual Attention. ICLR

Quick introduction to human gaze

Gaze Information to prime Object Detection

Dima Damen, Osian Haines, Andrew Calway and Walterio Mayol-Cuevas.

Object detection is based on the paper:
Dima Damen, Pished Bunnun, Andrew Calway and Walterio Mayol-Cuevas.
Real-time Learning and Detection of 3D Texture-less Objects: A Scalable Approach.
British Machine Vision Conference (BMVC), 2012. **[Best Poster Paper]**

Jan. 2013

University of BRISTOL

The Unique Problems

3. Attention and Task Relevance

Case Study: You-Do, I-Learn

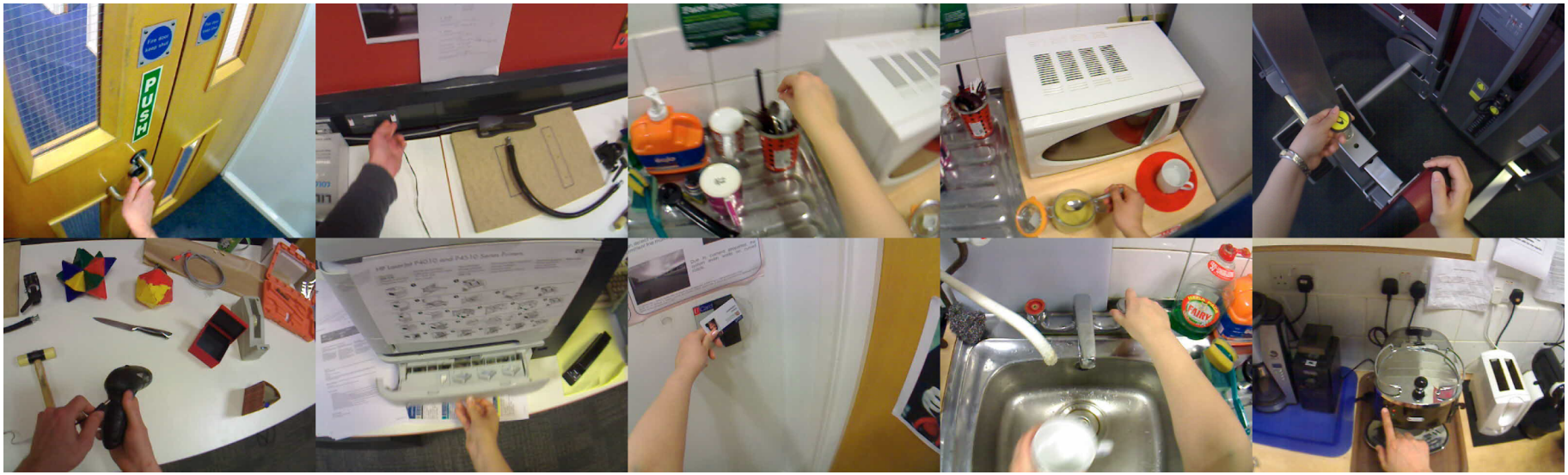
You-Do, I-Learn

- First-person view
- Offers a unique insight into ‘used’ or ‘attended-to’ objects
- How these objects have been used

D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

BEOID Dataset

- Released July 2014
- Wearable gaze tracker (ASL Mobile Eye XG)
- 6 locations: kitchen, workspace, printer, corridor with locked door, cardiac gym and weight-lifting machine
- 5 operators (2 sequences each)



D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

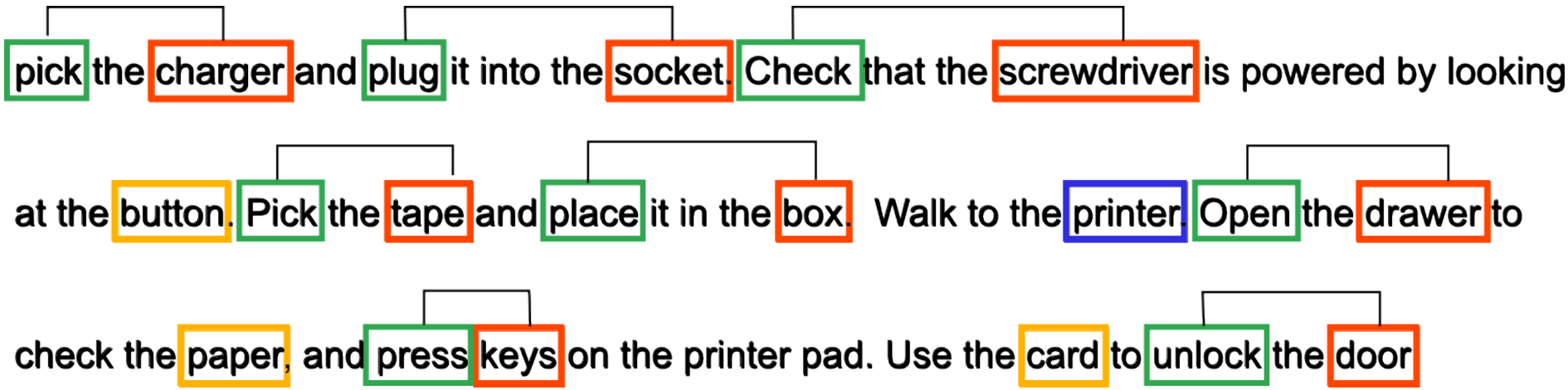
BEOID Dataset

- Q. How to ‘ground-truth’ objects that have been used?
- Q. How to ‘ground-truth’ how these objects have been used?

Try it yourself

BEOID

- Ground-truth by written narration
- Released with dataset



D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

You Do, I Learn

- Discover used objects
- Discover how objects have been used
- Extract guidance videos
- Fully unsupervised
  - No prior knowledge of objects (number, size)
  - Static and moveable objects

D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

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Teesid Leelasawassuk

Definition

Task-Relevant Object (TRO)

an object, or part of an object, with which a person interacts during task performance

Which Objects?

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Task-Relevant Objects

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Teesid Leelasawassuk

Discovering Task-Relevant Objects

- *Suggested* Problem Formulation…
  - Given a sequence of egocentric images $\{I_1, .., I_T\}$
  - Collected from multiple operators around a common environment
  - Automatically discover all task-relevant objects

$$\{O_k; 1 \leq k \leq K\}$$

$$O_k = \{\Omega(I_t); 1 \leq t \leq T\}$$

  - *Assumption:* at most one task-relevant image part is present within each image

D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

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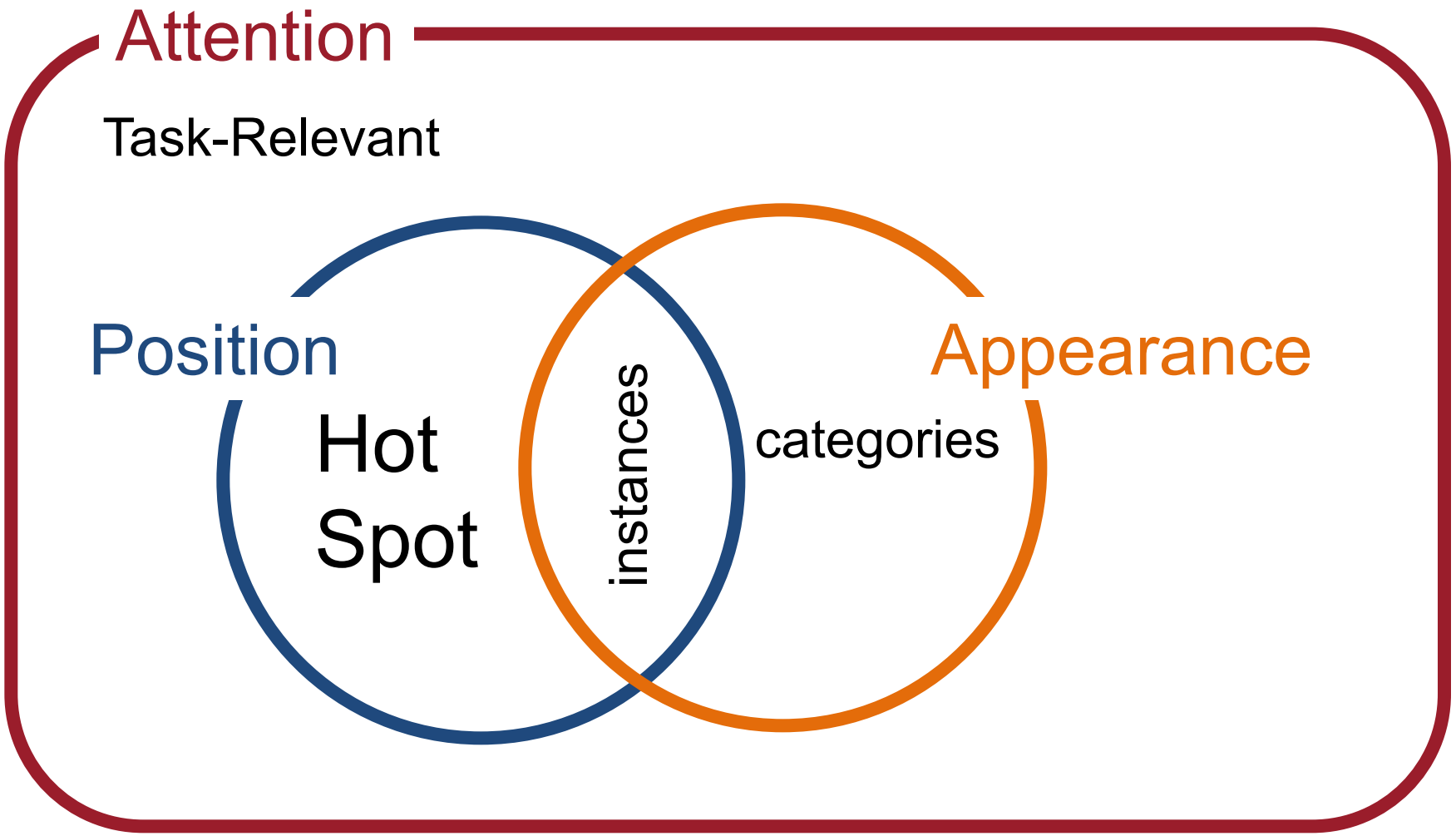
Teesid Leelasawassuk

Discovering Task-Relevant Objects



D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

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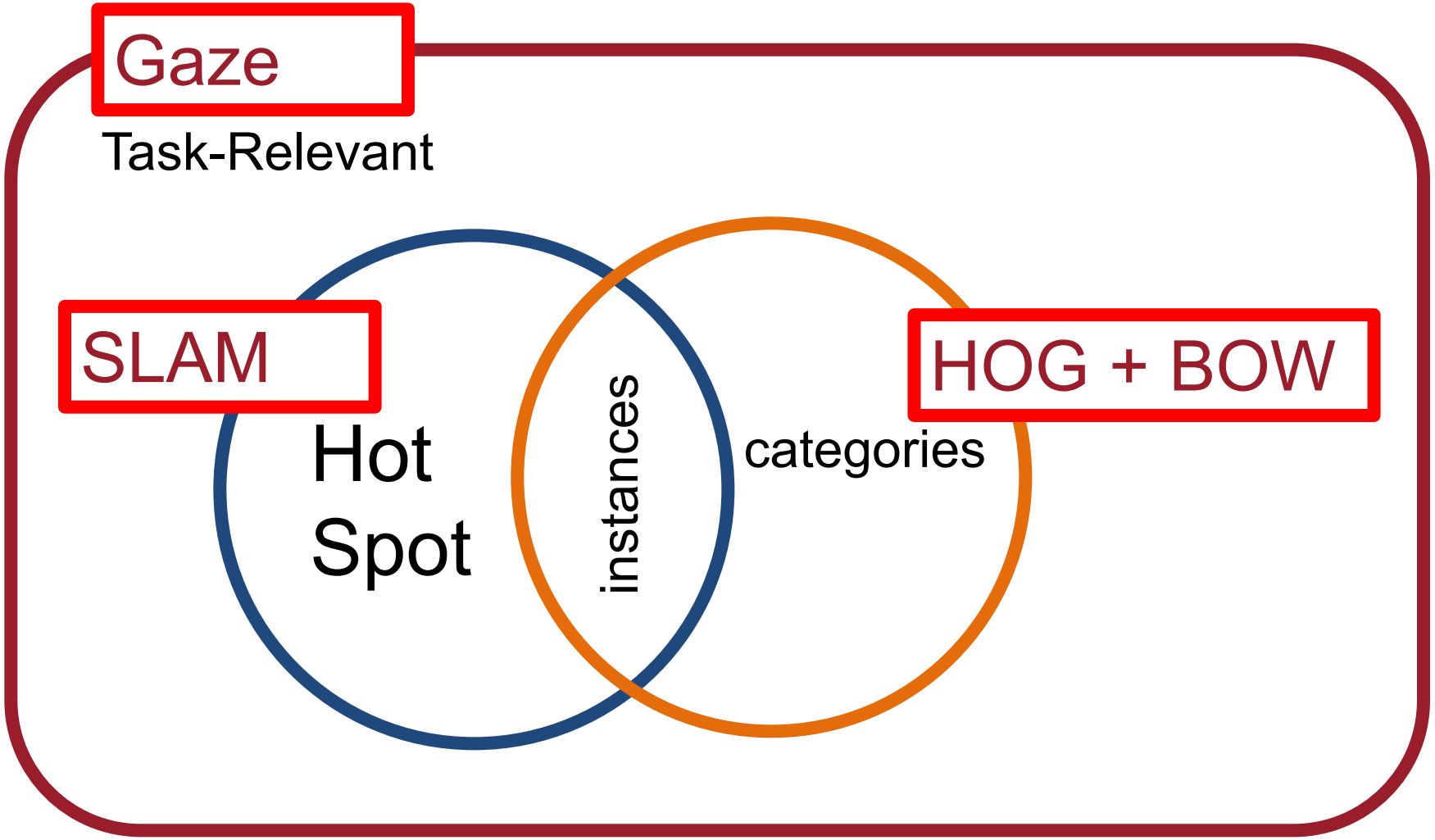
Teesid Leelasawassuk

Discovering Task-Relevant Objects



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Teesid Leelasawassuk

Discovering TROs

Discovering becomes a clustering task…

- Considers attention, position and appearance
- Unknown number of objects
- Davies-Bouldin (DB) index
- K-Means vs Spectral

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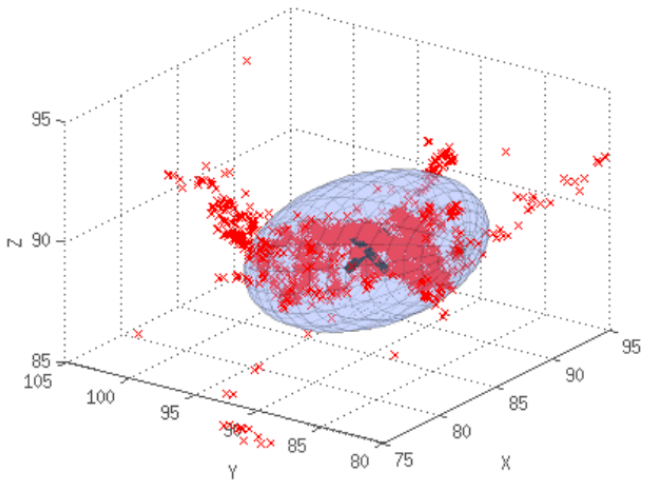
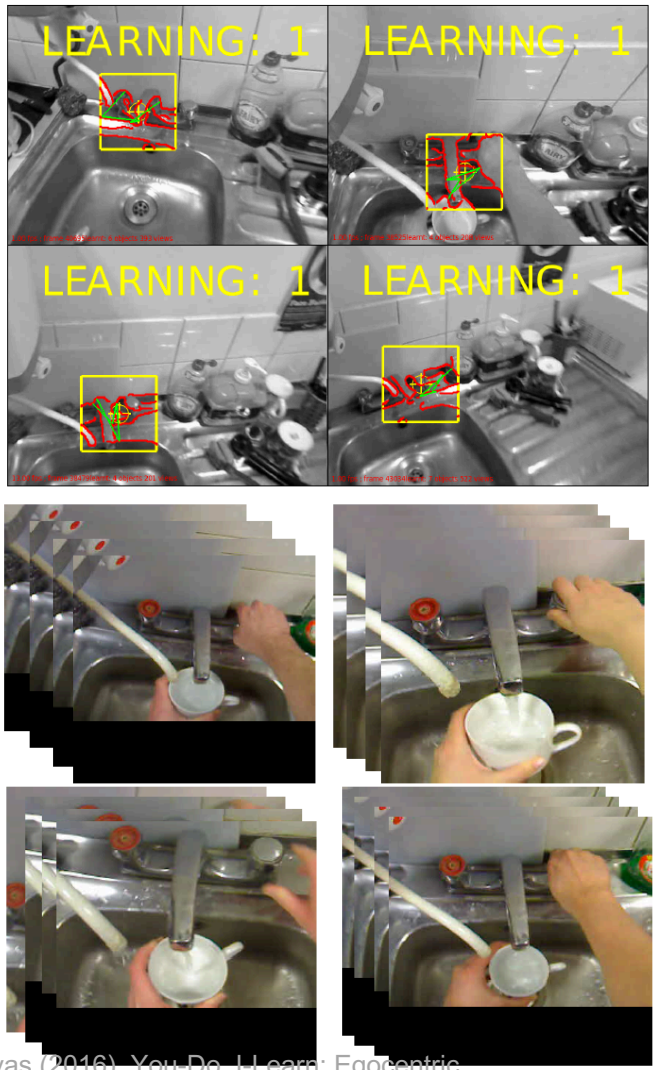
Teesid Leelasawassuk

Discovering Task-Relevant Objects

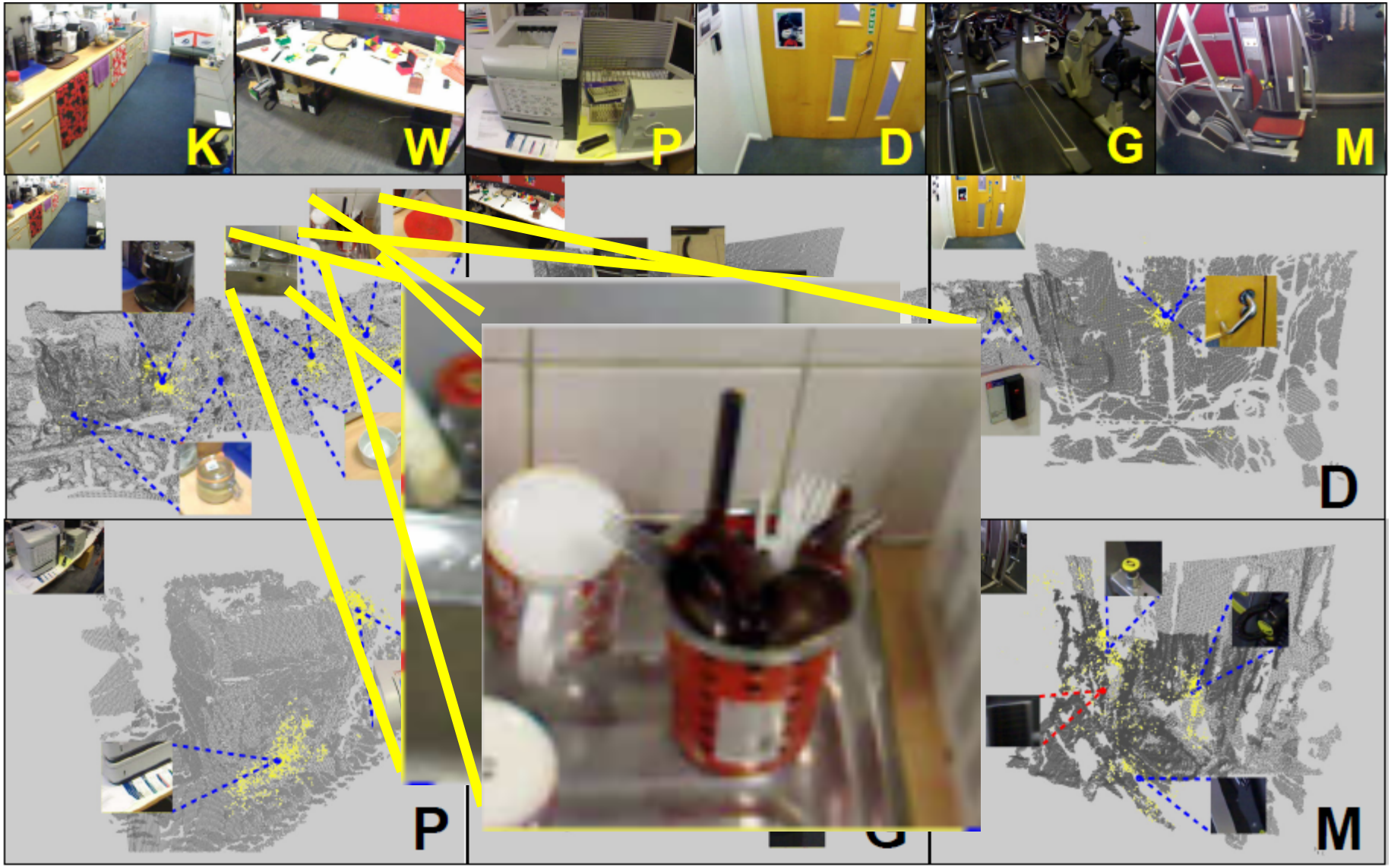




D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

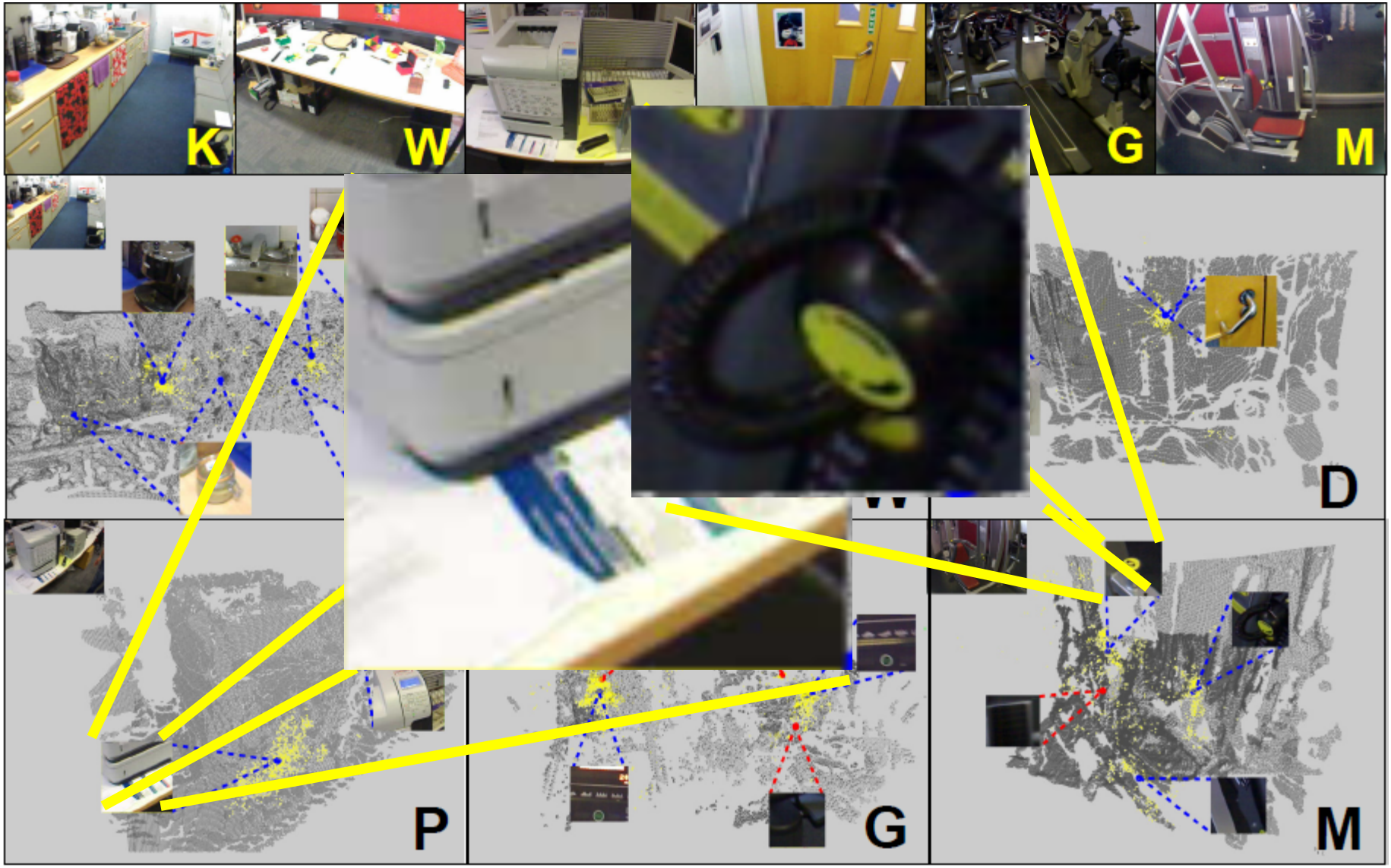
with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Task-Relevant Objects



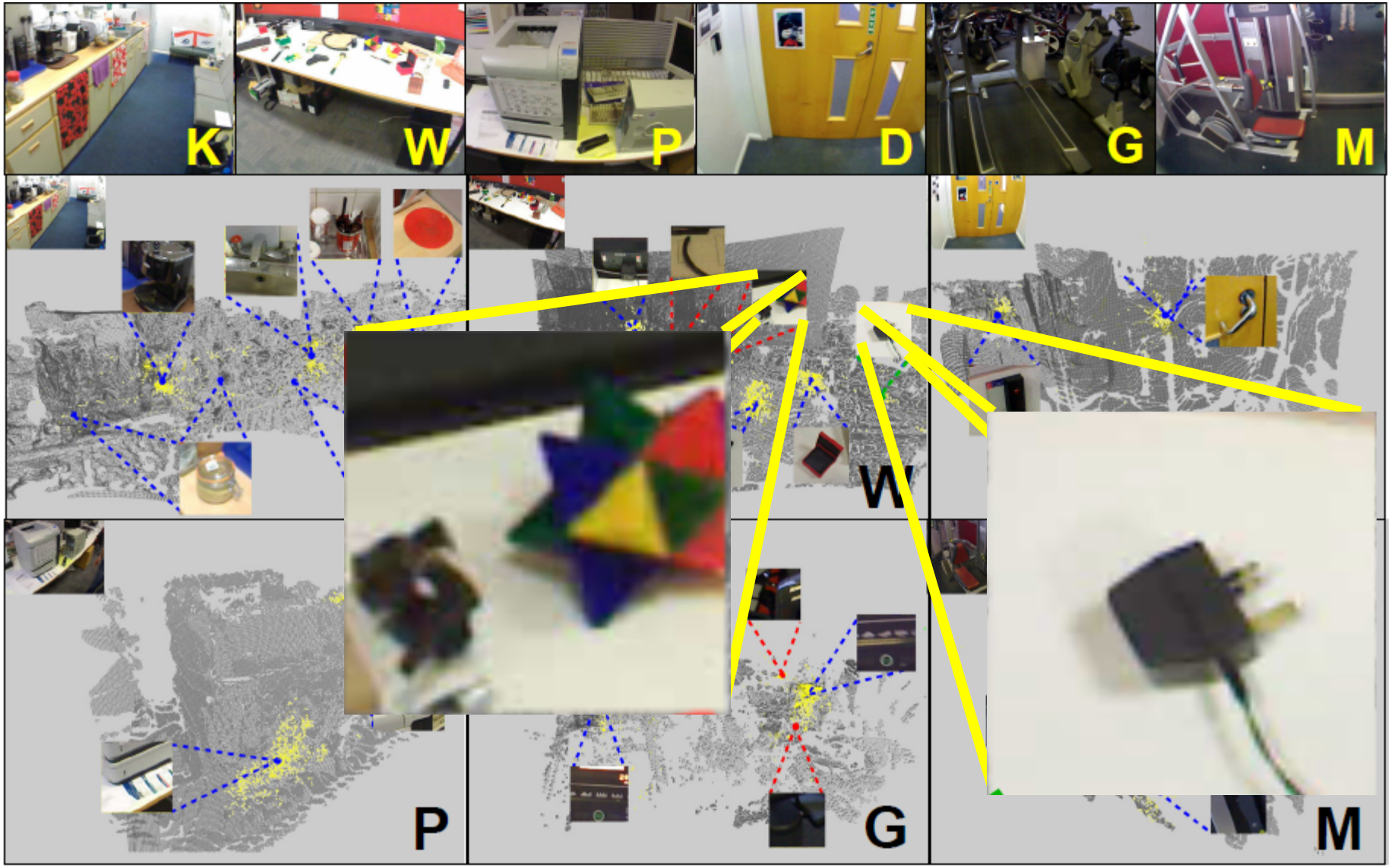
with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Task-Relevant Objects



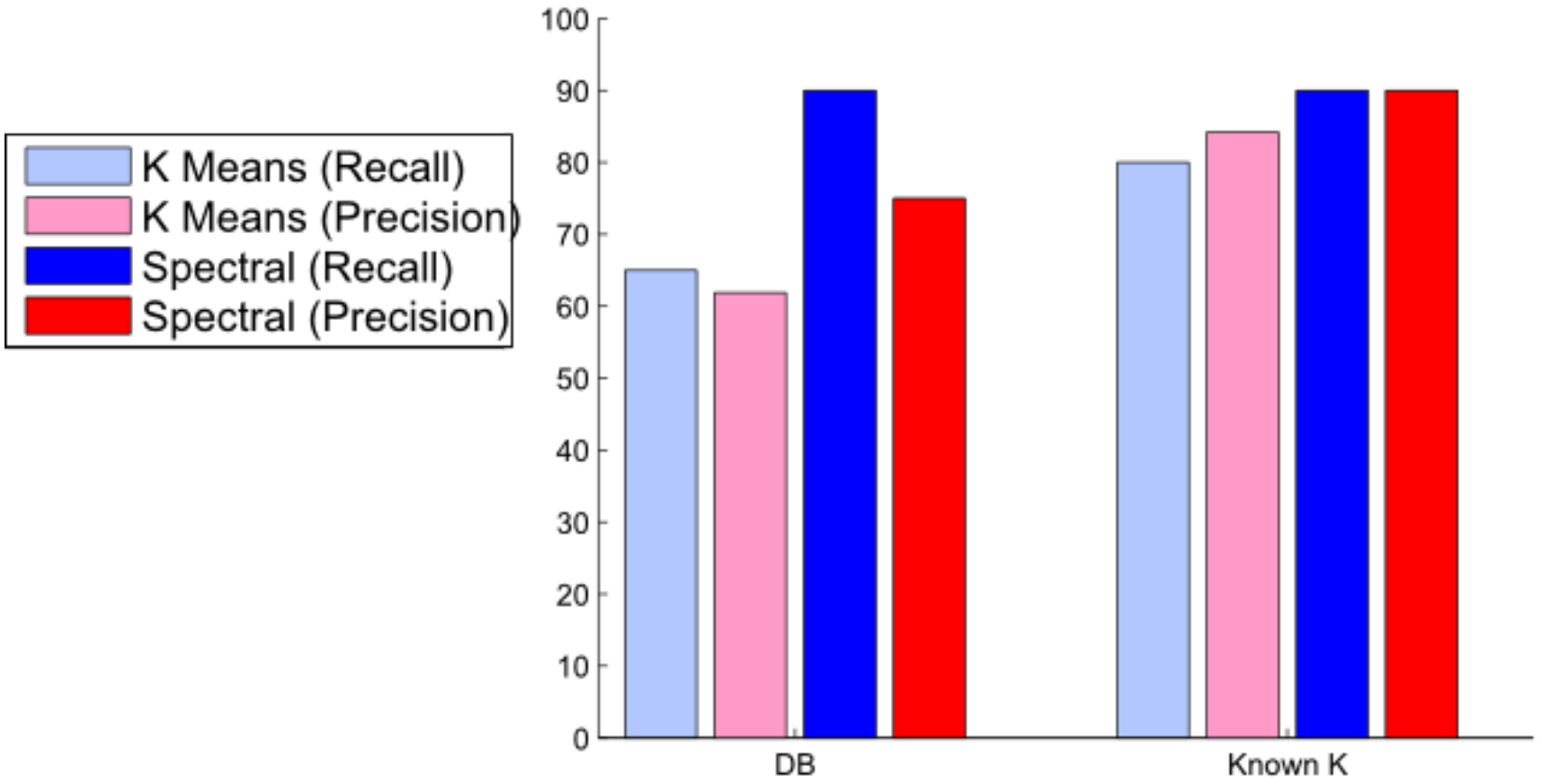
with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Task-Relevant Objects



with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Task-Relevant Objects



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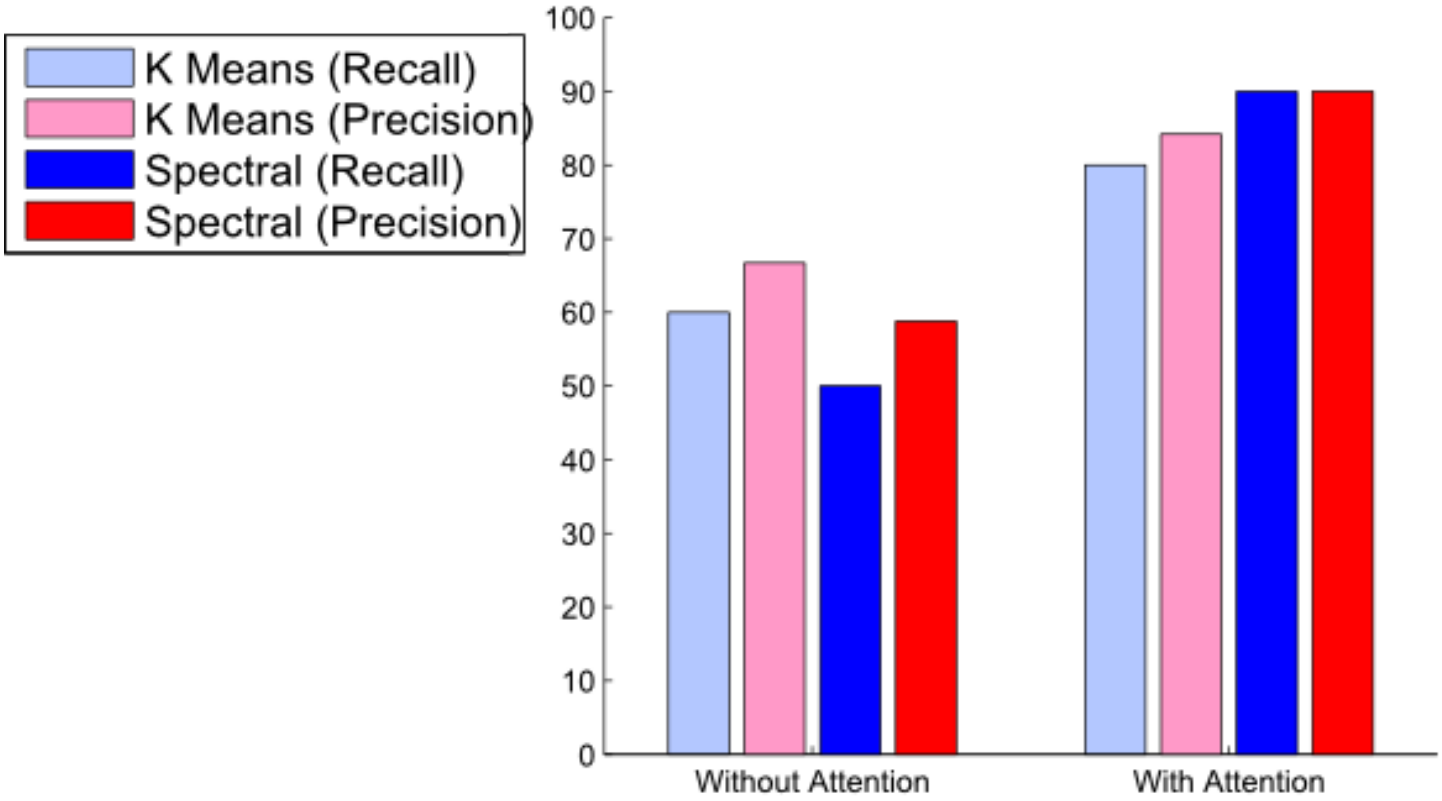
Teesid Leelasawassuk

Discovering Task-Relevant Objects



D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Modes of Interaction

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Definition

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Modes of Interaction (MOI)

the different ways in which TROs are used

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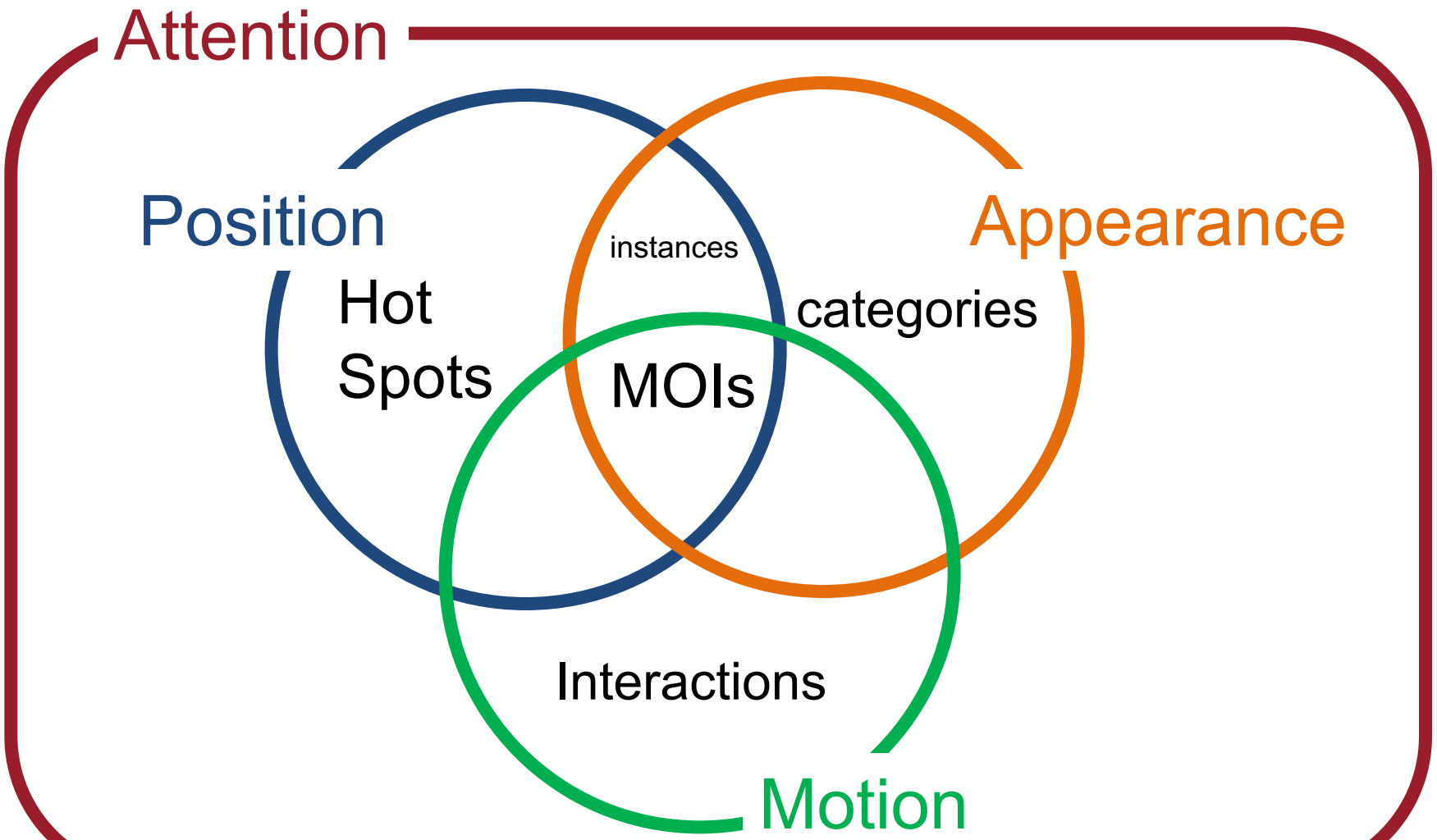
with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Modes of Interaction



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Teesid Leelasawassuk

Discovering Modes of Interaction

- Motion
  - Video snippets for each discovered object
  - Descriptor per snippet
  - Clustering using DB-index

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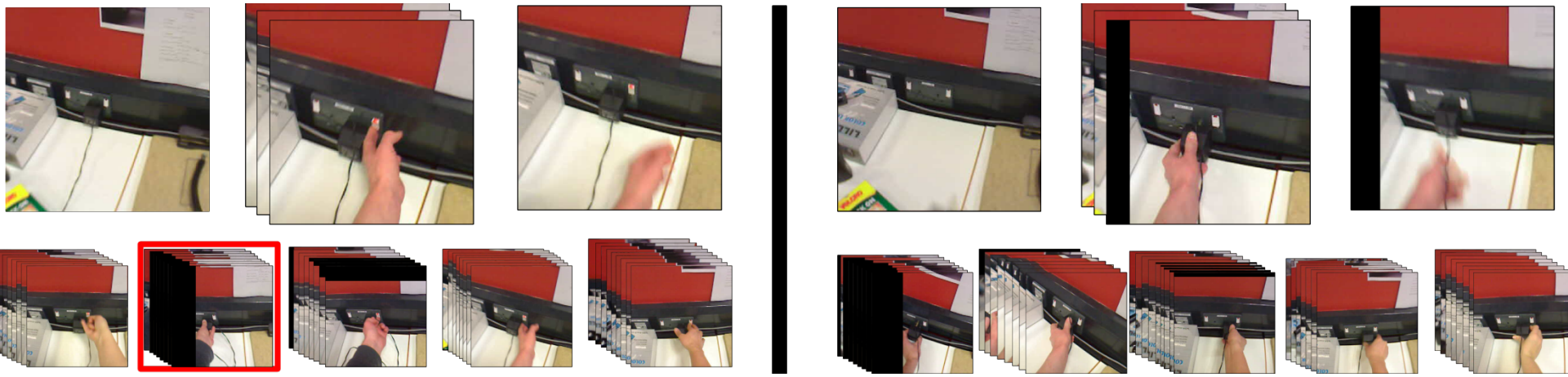
Discovering Modes of Interaction



D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

Discovering Modes of Interaction

Open & get sugar

Put

Pick

Open door

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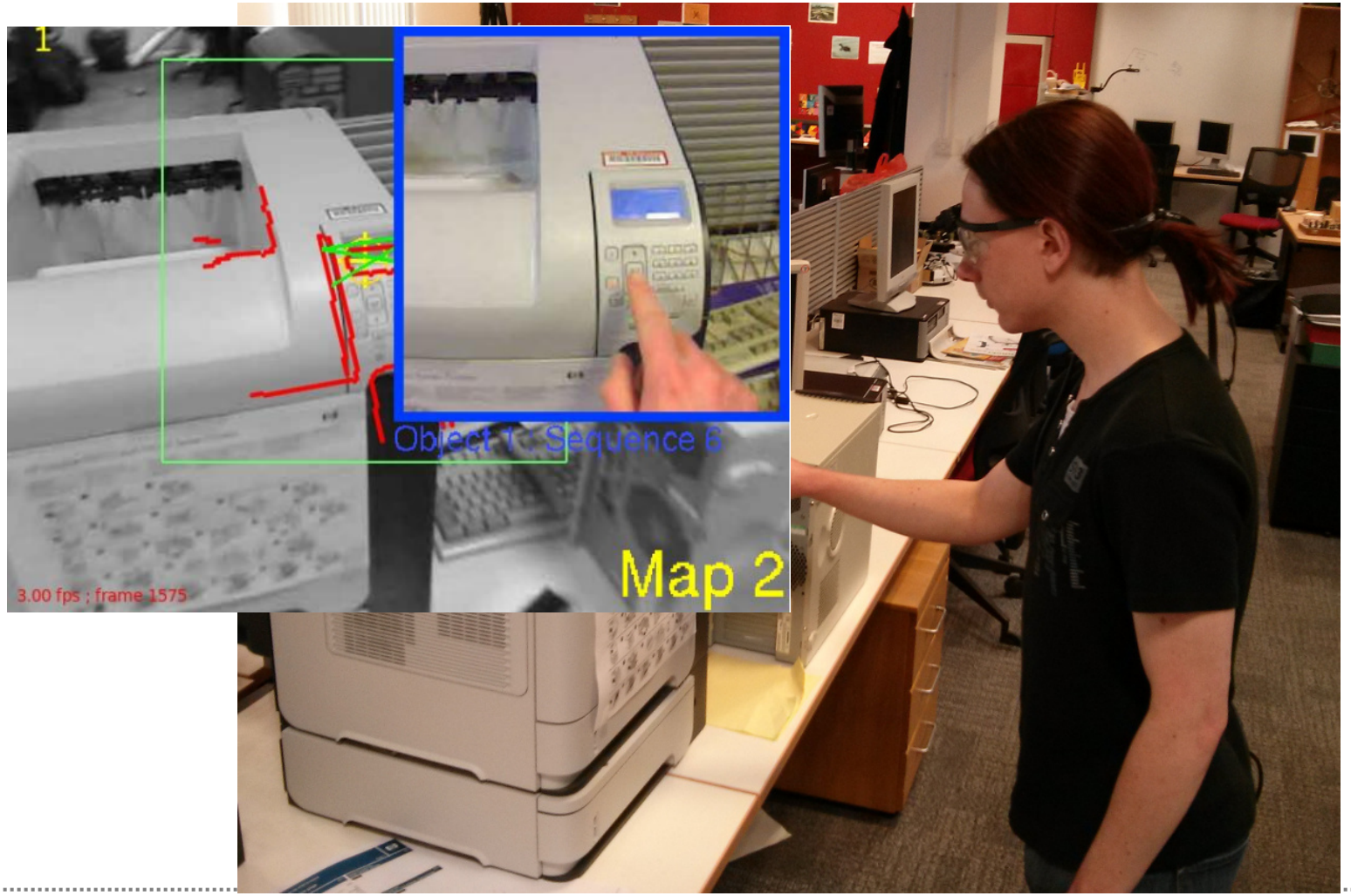
Teesid Leelasawassuk

Back to…. the goal…



D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

You Do, I Learn - Demonstration

D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

You Do, I Learn – Google Glass Prototype

T Leelasawassuk, D Damen, W Mayol-Cuevas (2017). Automated capture and delivery of assistive task guidance with an eyewear computer: The GlaciAR system. *Augmented Human*

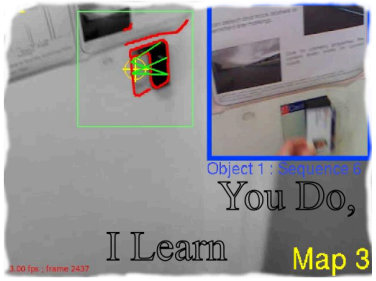
Task Monitoring - 2017

with: Longfei Chen
Kazuaki Kondo
Yuichi Nakamura
Walterio Mayol-Cuevas

L Chen et al (2017). Hotspots Detection for Machine Operation in Egocentric Vision. IAPR conference on *Machine Vision Applications*

More info…

Project You-Do, I-Learn



Video1 (2014), Video2 (2017)

Automated capture and delivery of assistive task guidance with an eyewear computer: The GlaciAR system. T Leelasawassuk, D Damen, W Mayol-Cuevas. Augmented Human, Mar 2017 pdf

You-Do, I-Learn: Discovering Task Relevant Objects and their Modes of Interaction from Multi-User Egocentric Video. D Damen, T Leelasawassuk, O Haines, A Calway, W Mayol-Cuevas. British Machine Vision Conference (BMVC), Sep 2014. PDF | Abstract | Dataset

Multi-user egocentric Online System for Unsupervised Assistance on Object Usage. D Damen, O Haines, T Leelasawassuk, A Calway, W Mayol-Cuevas. ECCV Workshop on Assistive Computer Vision and Robotics (ACVR), Sep 2014. PDF Preprint

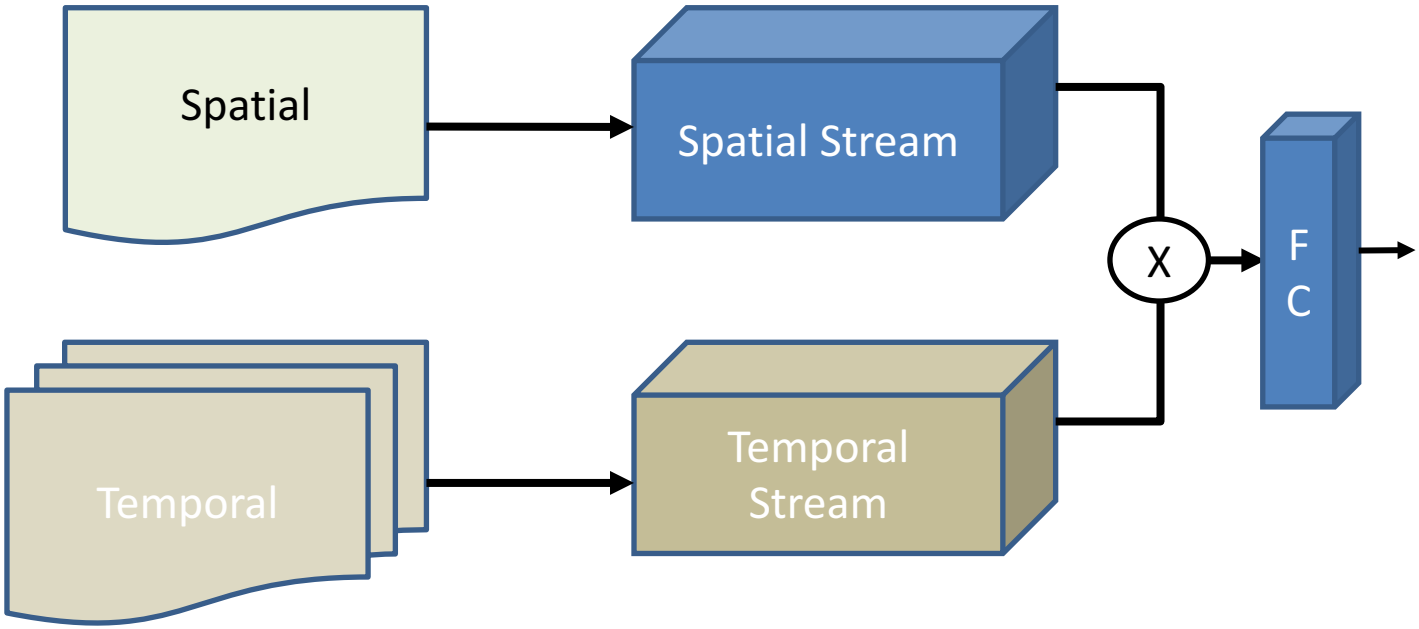
Estimating Visual Attention from a Head Mounted IMU. T Leelasawassuk, D Damen, W Mayol-Cuevas. International Symposium on Wearable Computers (ISWC), Sep 2015. PDF

The Unique Problems

4. Object Interactions

Action Recognition – an Introduction

- CNNs for Action Recognition
  1. Dual-Stream Neural Networks



Action Recognition – an Introduction

- CNNs for Action Recognition
  1. Dual-Stream Neural Networks

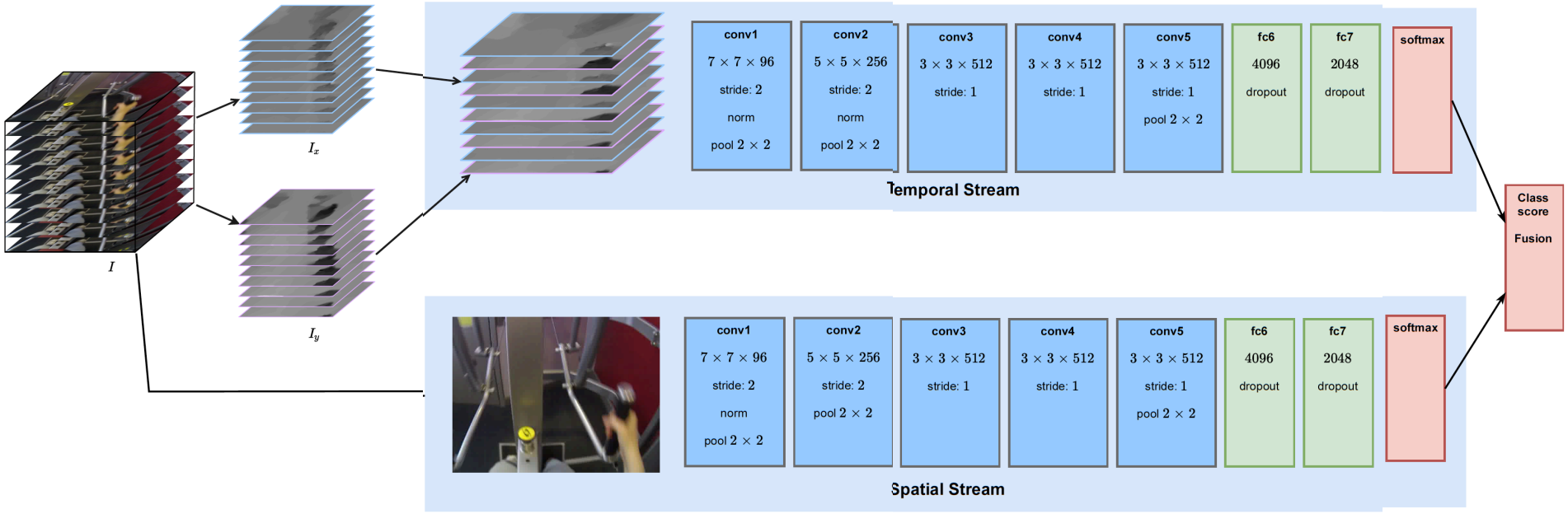


Figure by: Will Price, BSc Project, University of Bristol

Action Recognition – an Introduction

- CNNs for Action Recognition
  1. Dual-Stream Neural Networks

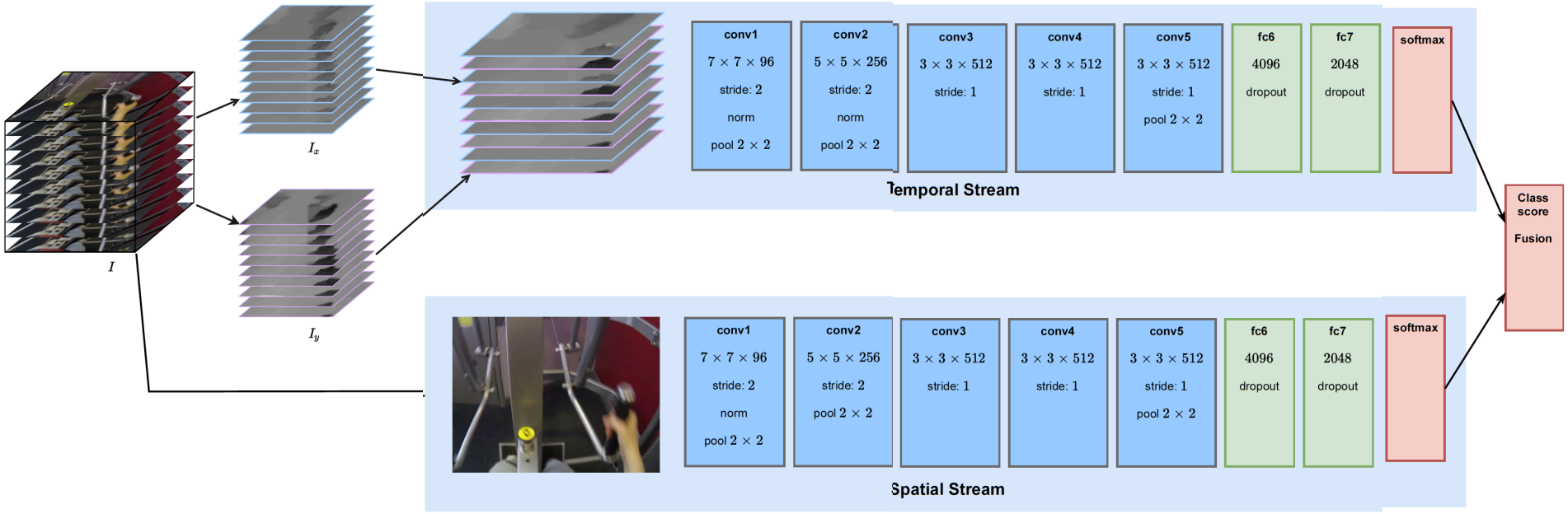


Figure by: Will Price, BSc Project, University of Bristol

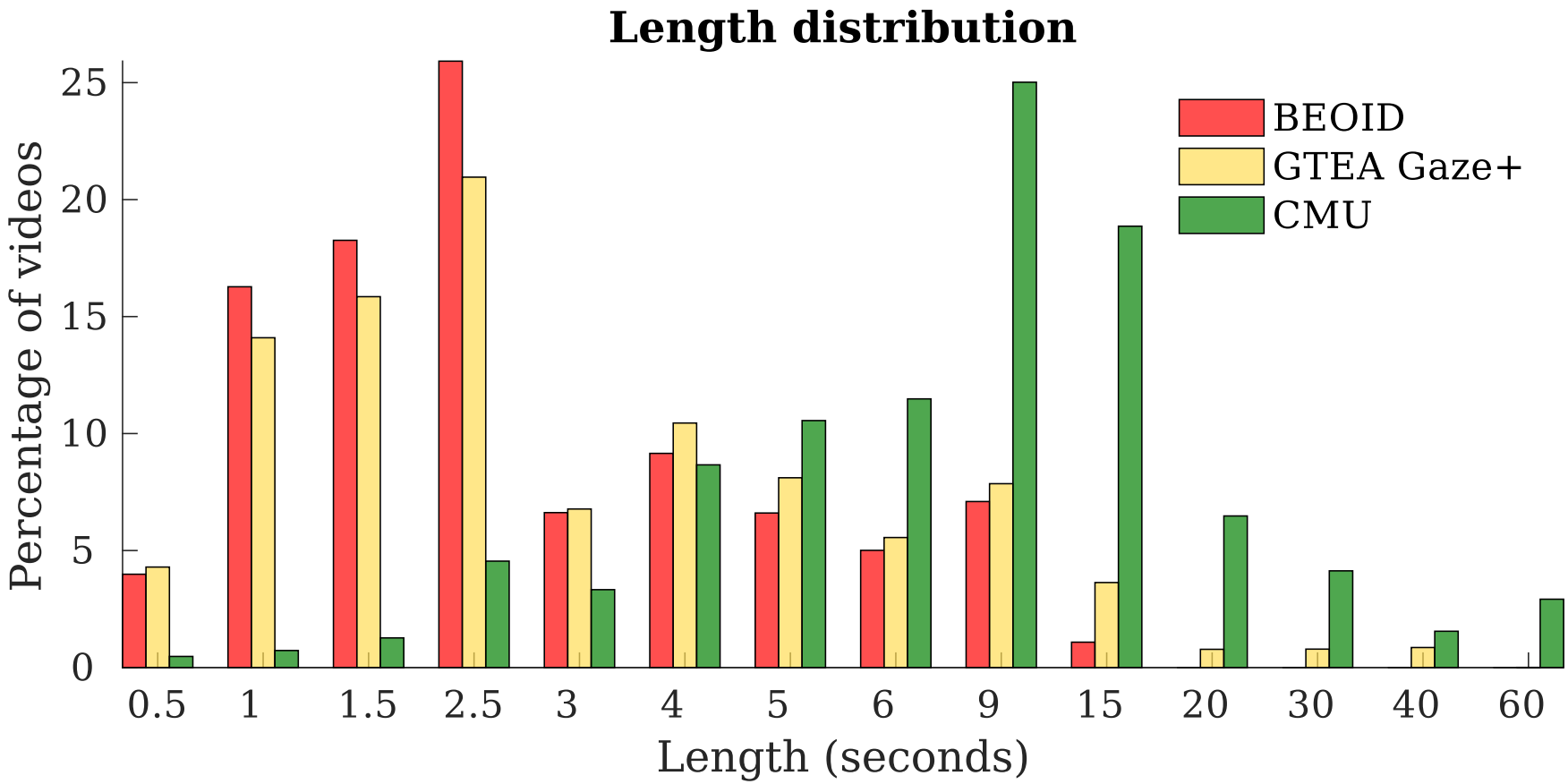
Action Recognition – an Introduction

with: Davide Moltisanti
Michael Wray
Walterio Mayol-Cuevas

Dataset	N. of *gt* segments	N. of *gen* segments	Classes
BEOID [1]	742	16691	34
GTEA Gaze+ [6]	1141	22221	42
CMU [2]	450	26160	31

Action Recognition – an Introduction

with: Davide Moltisanti
Michael Wray
Walterio Mayol-Cuevas



Egocentric Action Recognition

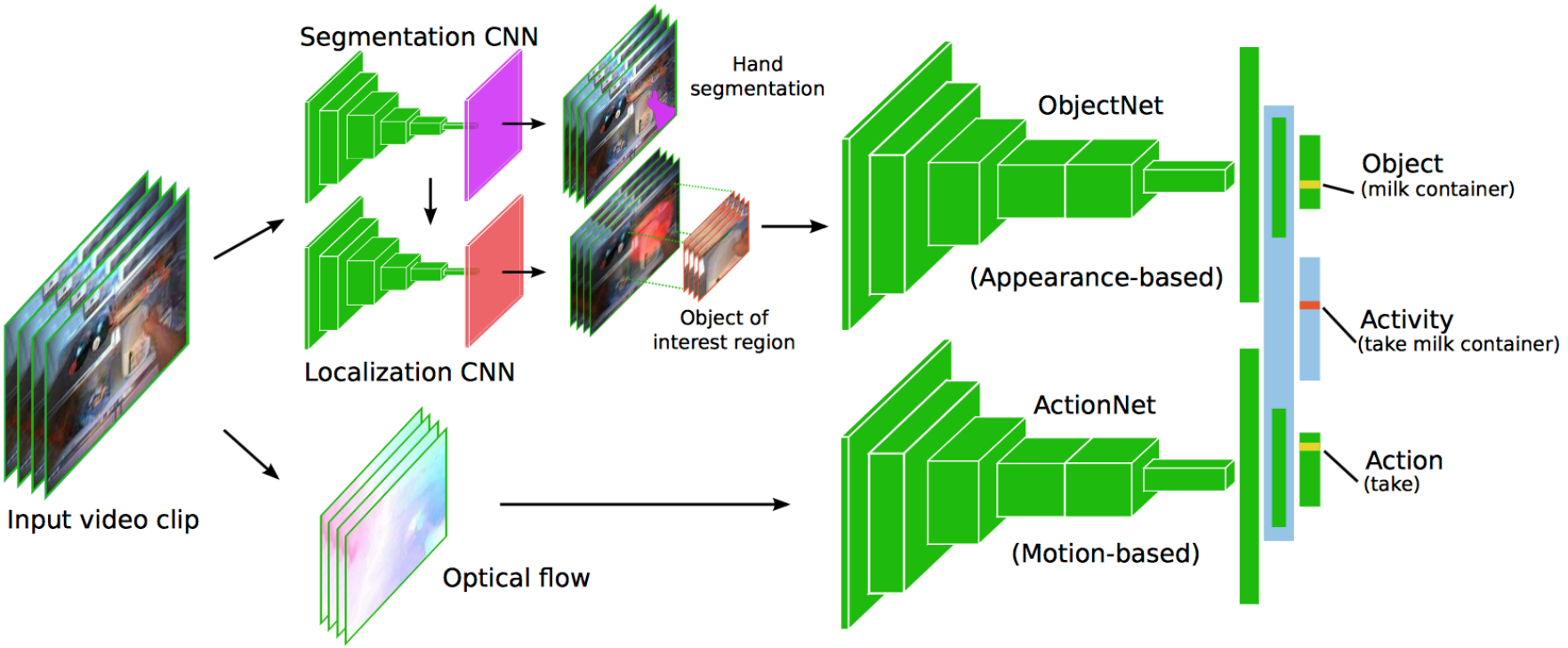
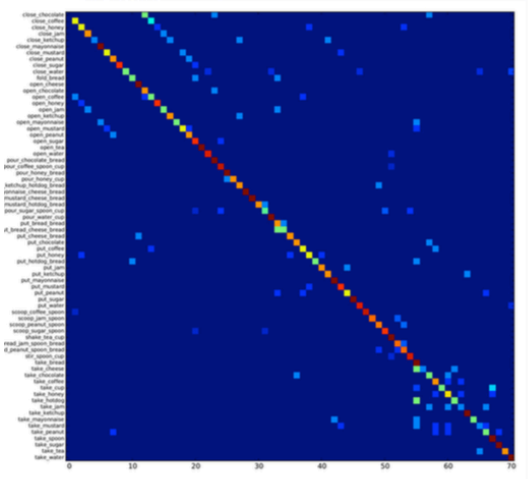
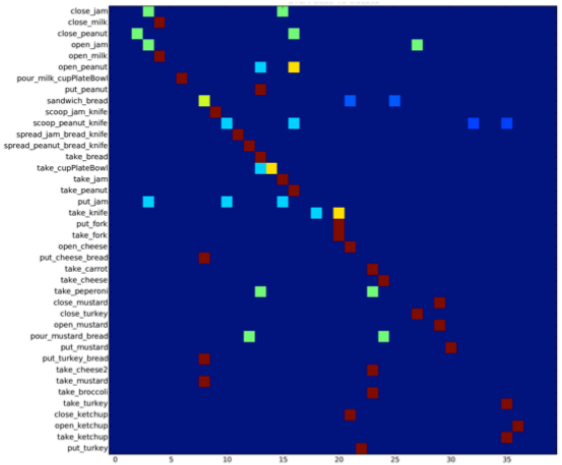


Figure from: Ma et al. Going Deeper into First-Person Activity Recognition. CVPR 2016

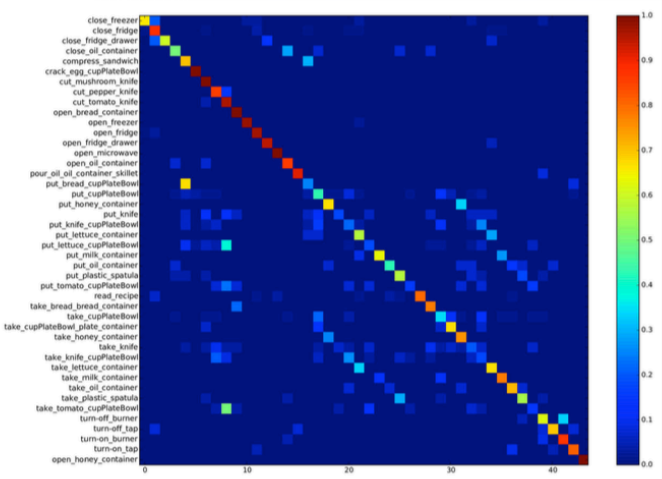
Egocentric Action Recognition



(a) GTEA 71 classes



(b) Gaze 40 classes



(c) Gaze+ 44 classes

Egocentric Action Recognition

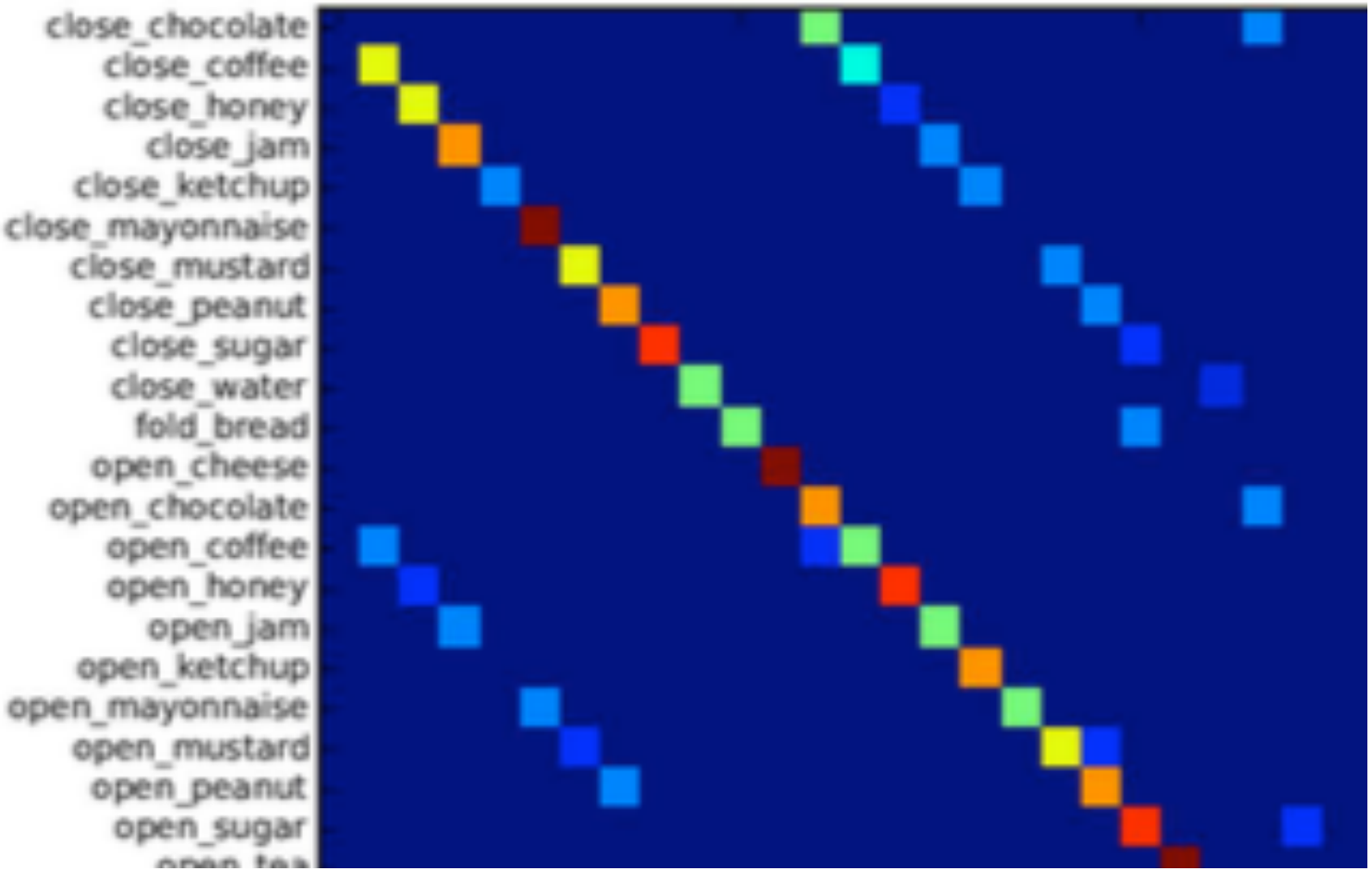


Figure from: Ma et al. Going Deeper into First-Person Activity Recognition. CVPR 2016

Action Recognition – an Introduction

- CNNs for Action Recognition
  1. Dual-Stream Neural Networks

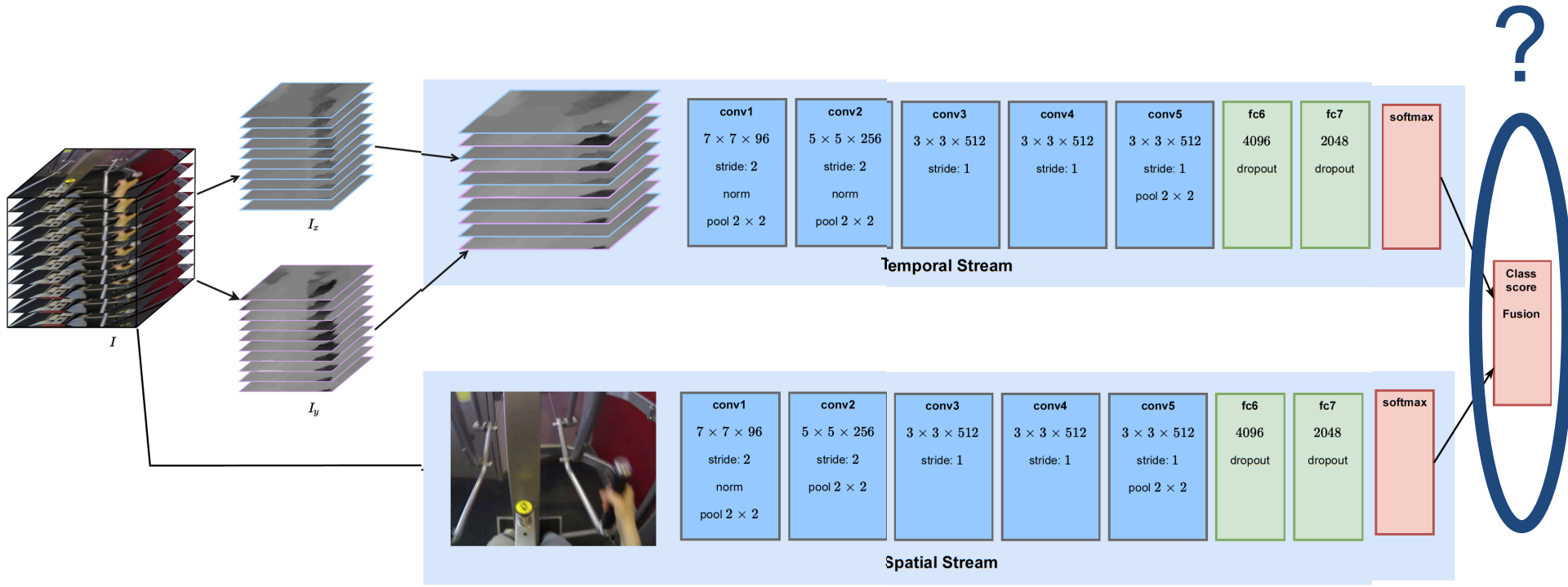
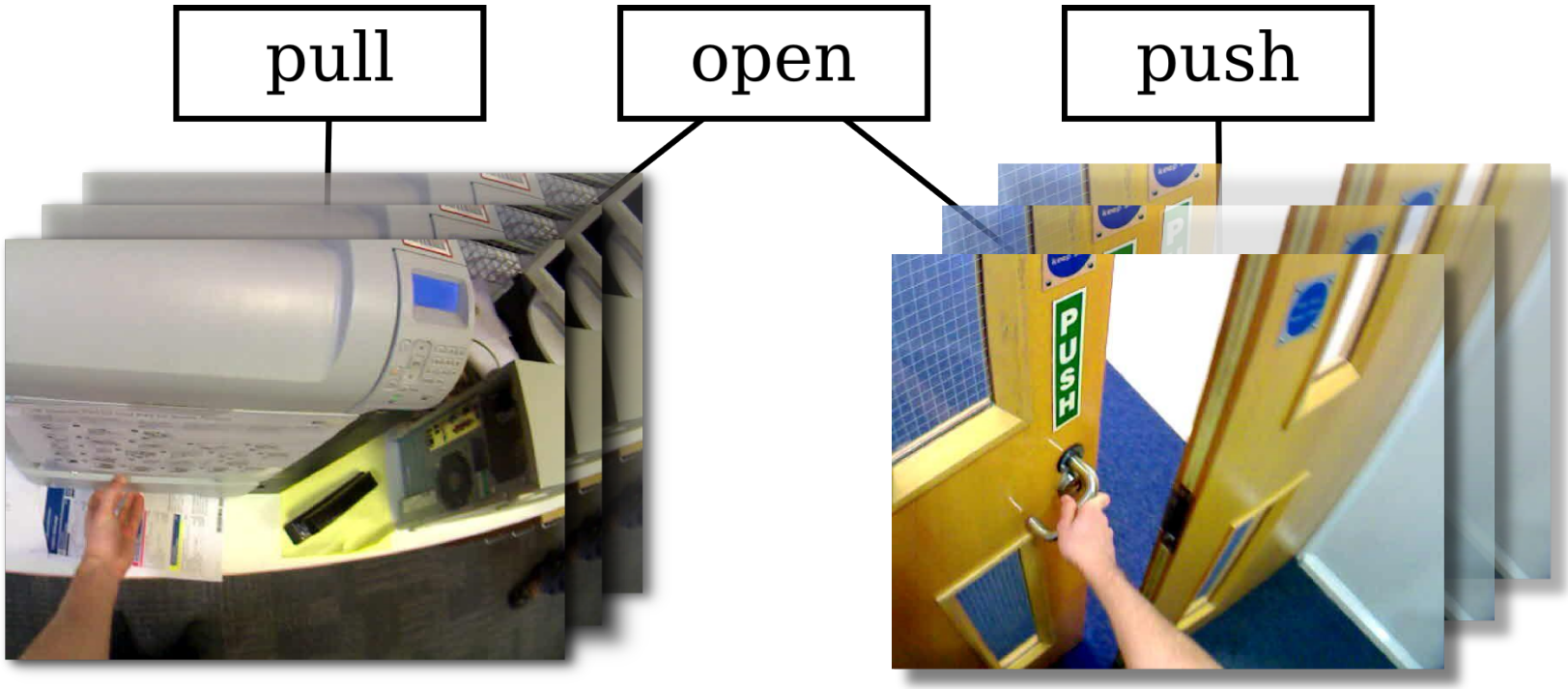


Figure by: Will Price, BSc Project, University of Bristol

Object Interactions – the Dilemma

with: Michael Wray
Davide Moltisanti
Walterio Mayol-Cuevas



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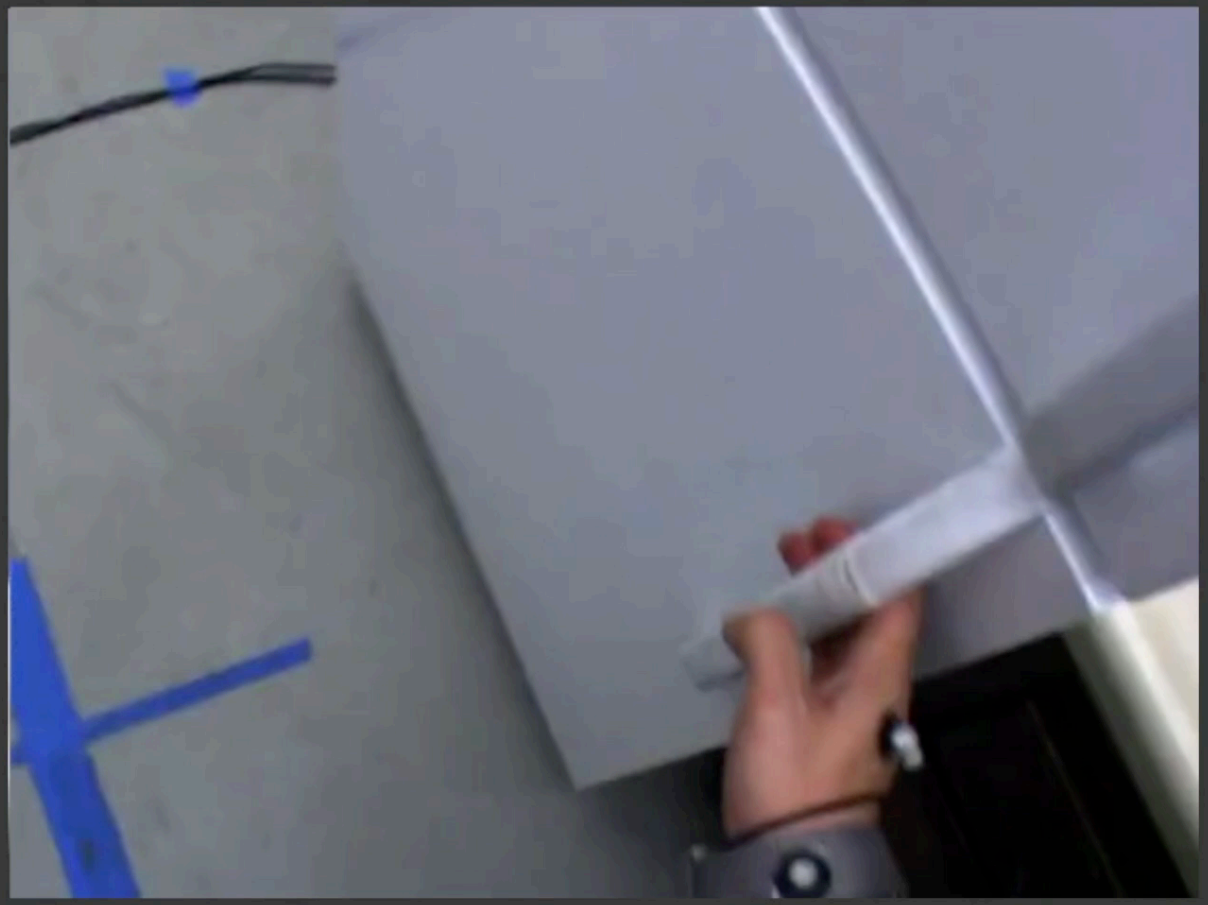

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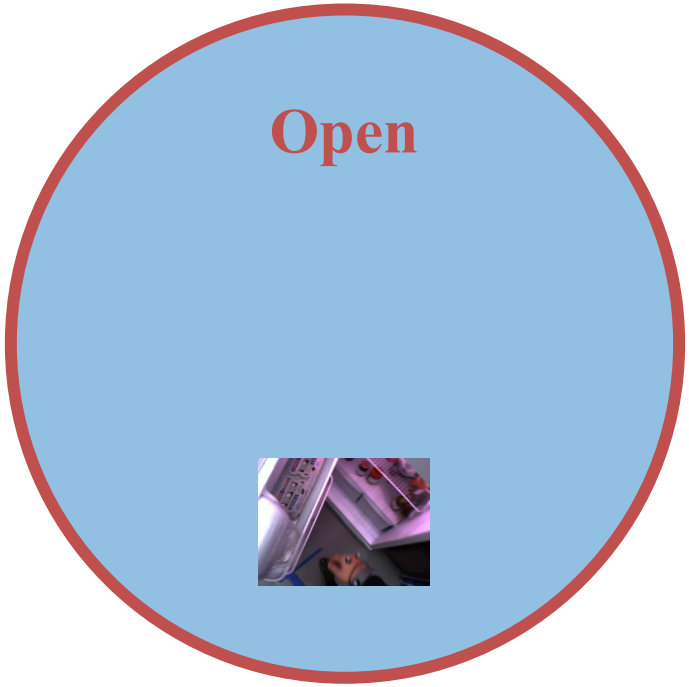

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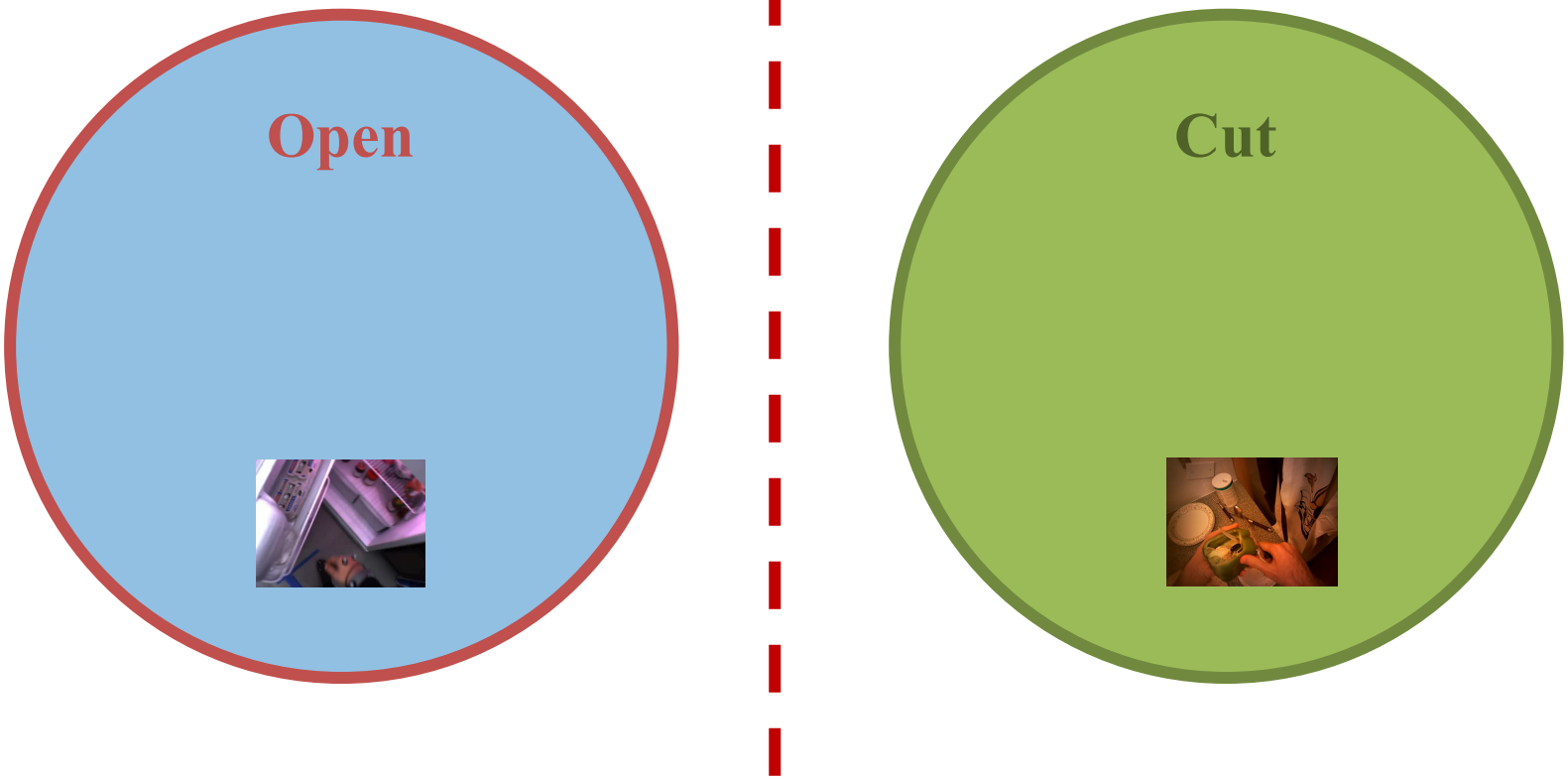

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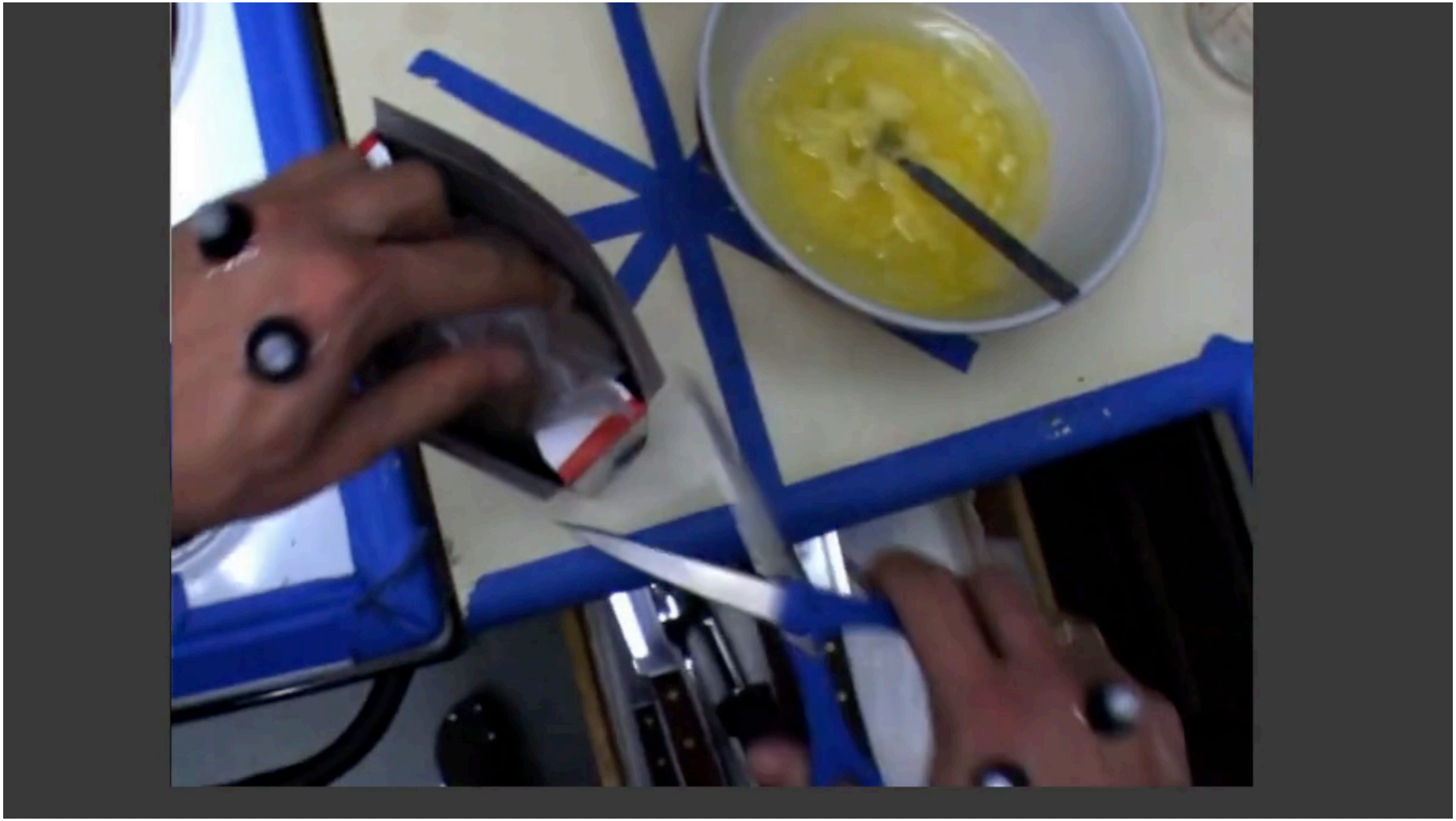

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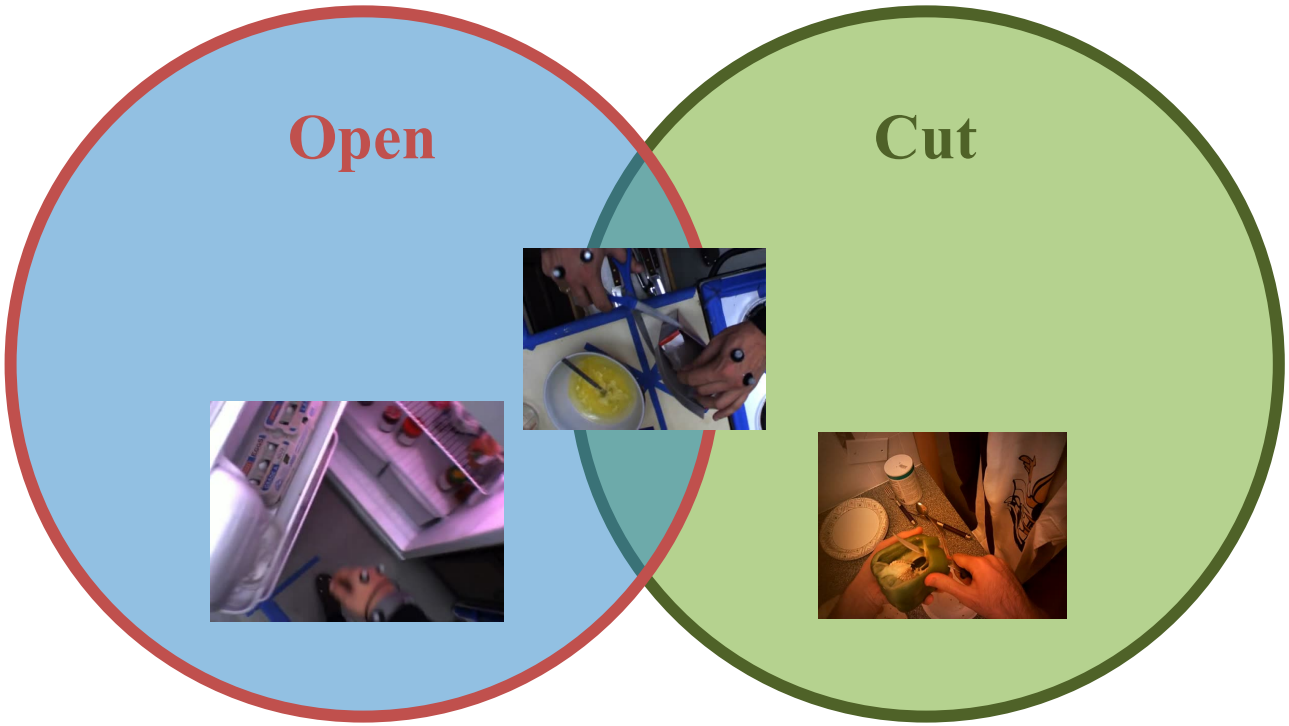

Object Interactions – the Dilemma

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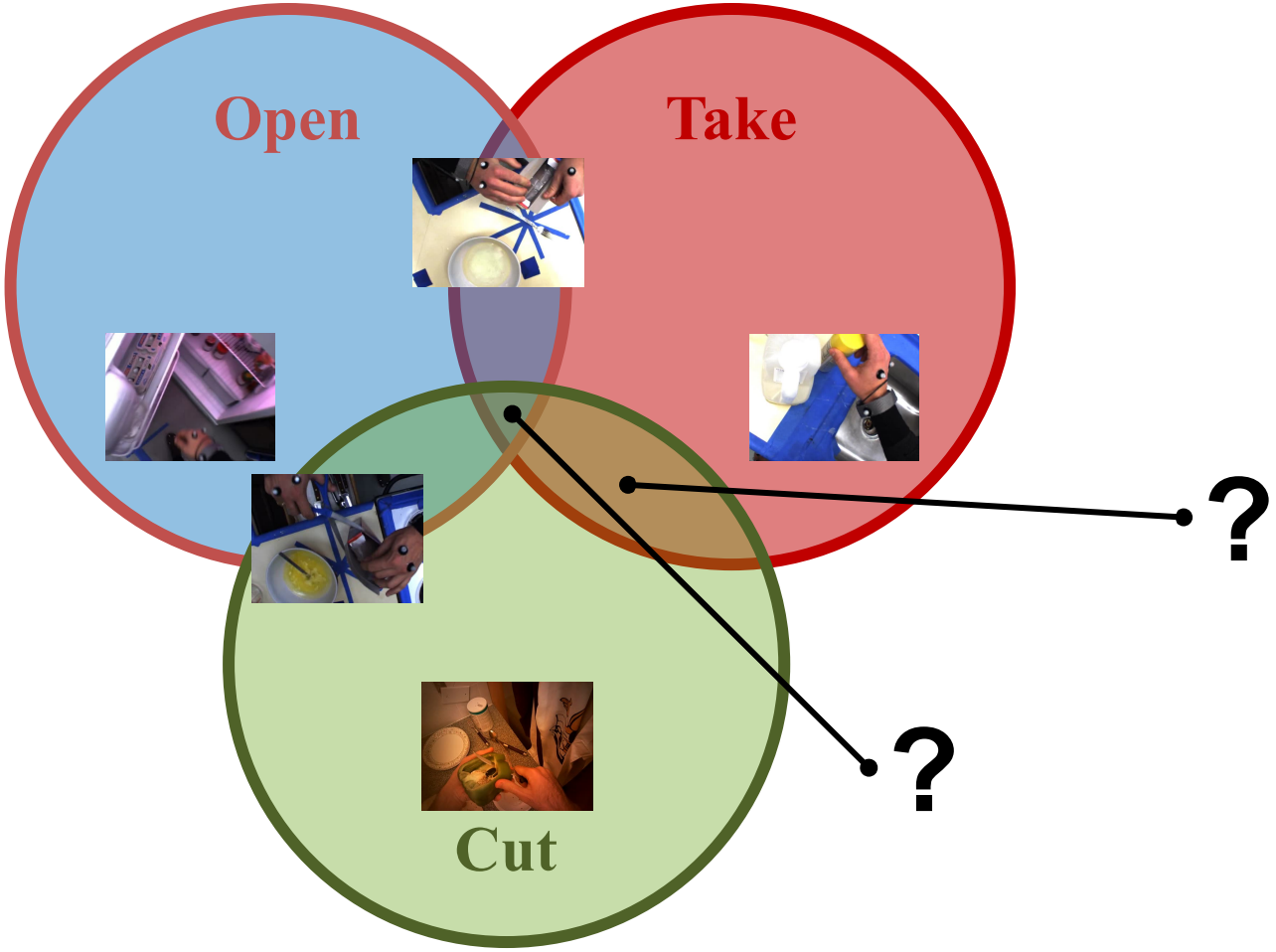


Object Interactions – the Dilemma

with: Michael Wray
Davide Moltisanti
Walterio Mayol-Cuevas

- Verbs cannot be separated into classes with hard boundaries.
- Rather the boundaries are more nuanced – what is correct in one video is incorrect for another.
- Singular classes are not enough.

Visualising Learnt Models

- BEOID EBP videos:
  https://youtu.be/Fu7Db7Pau_A
  https://youtu.be/4aDwQ-a3M68

The Unique Problems

5. Multi-View Action Recognition

FPV with SPV

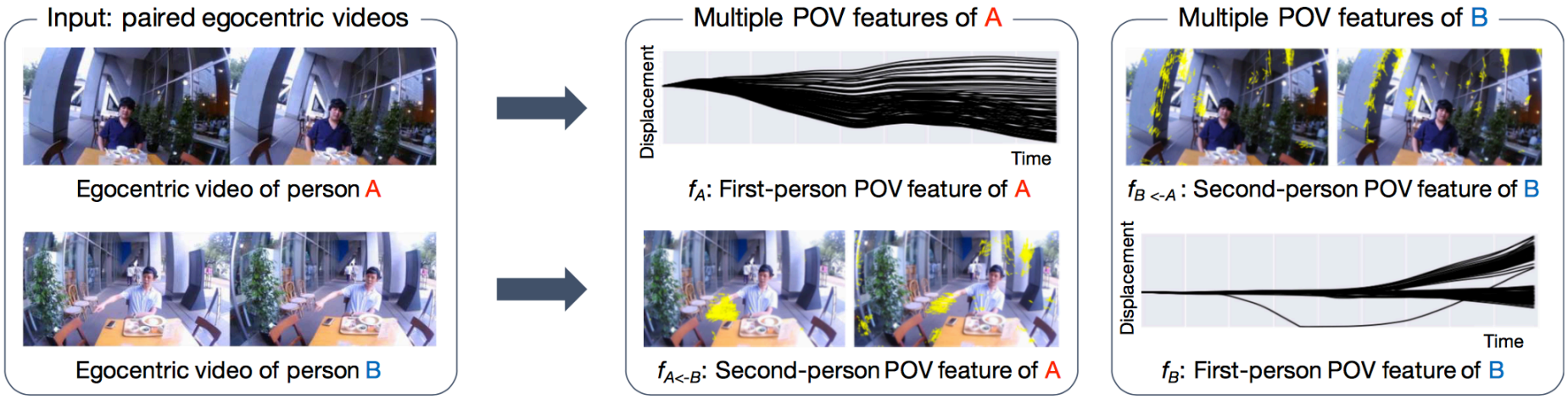


Figure from: Yonetani et al (2016). Recognizing Micro-Actions and Reactions From Paired Egocentric Videos. CVPR

FPV with TPV (top-view)

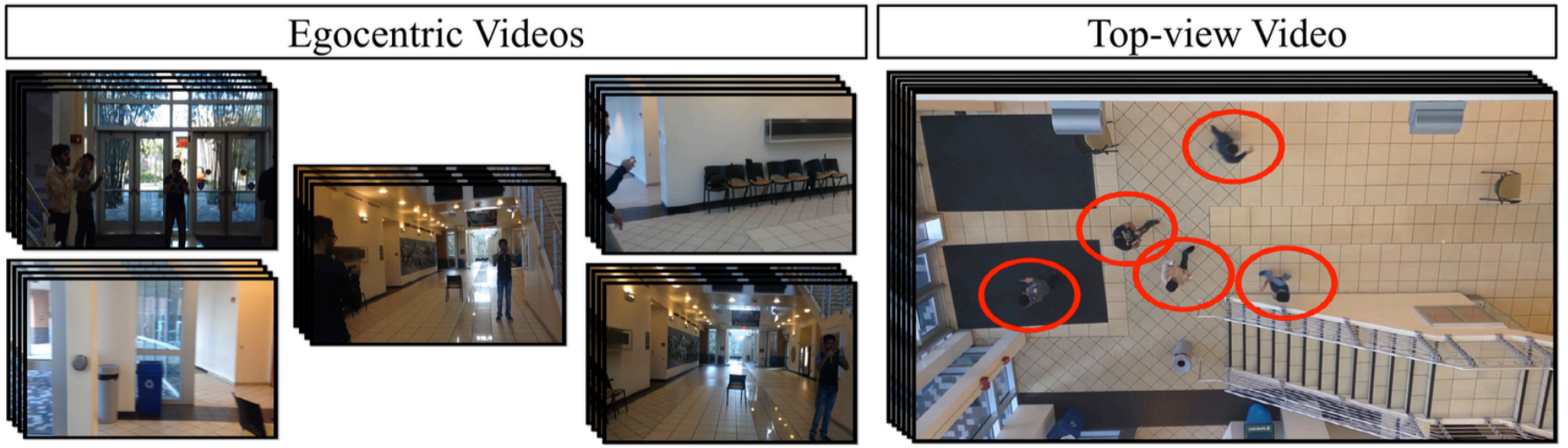


Figure from: Ardeshir and Borji (2016). Egocentric Meets Top-view CVPR

FPV with TPV (top-view)

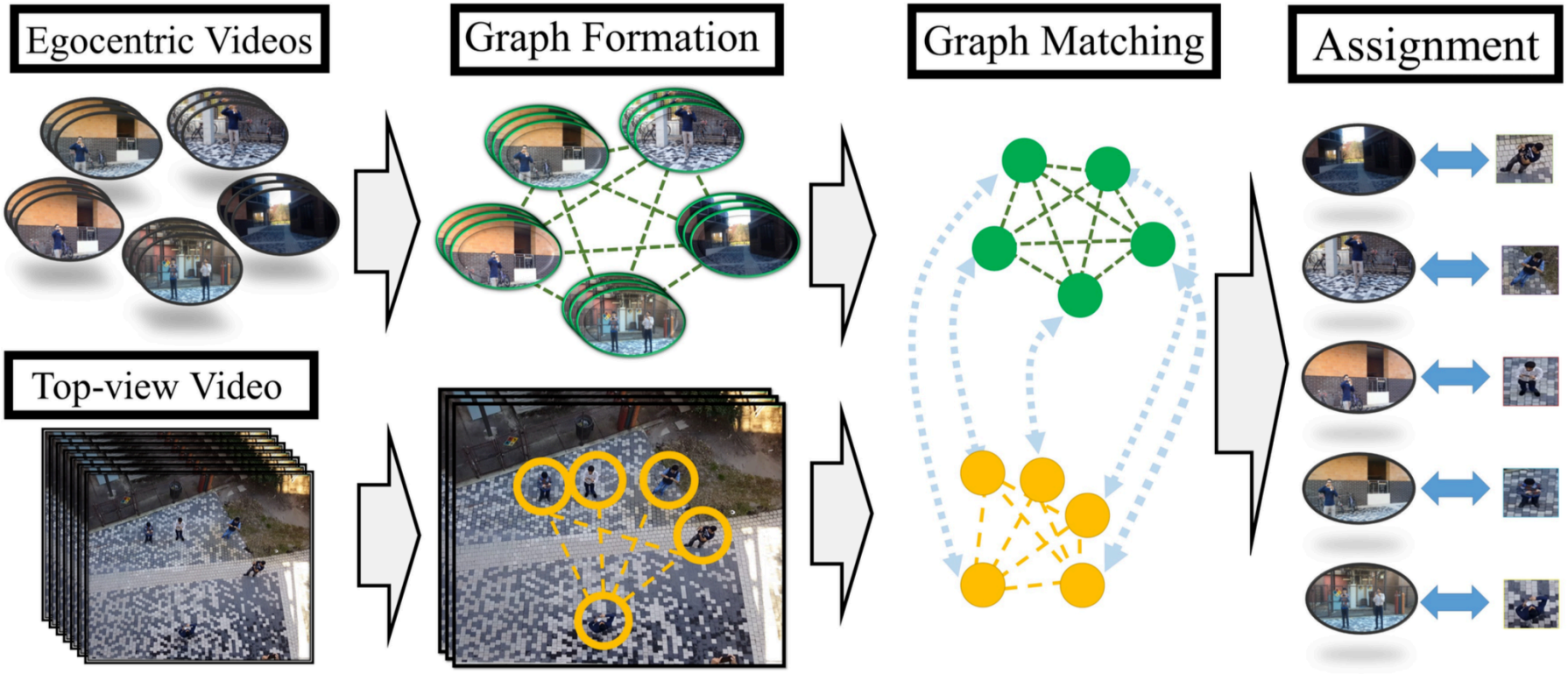


Figure from: Ardeshir and Borji (2016). Ego2Top: Matching Viewers in Egocentric and Top-view Videos. ECCV

Egocentric Vision

- The Unique Problems
  1. Camera Motion
  2. Mapping and Localisation (ref tomorrow's talk)
  3. Attention and Task-Relevance
  4. Object Interactions
  5. Multi-view Solutions
- The Unique Applications
  1. Video Summarisation
  2. Skill Determination
  3. Real-time solutions

The Unique Applications

1. Video Summarisation

Video Summarisation

- Fixations
- Highlight Detection

Egocentric Video Summarisation

- Object-Driven

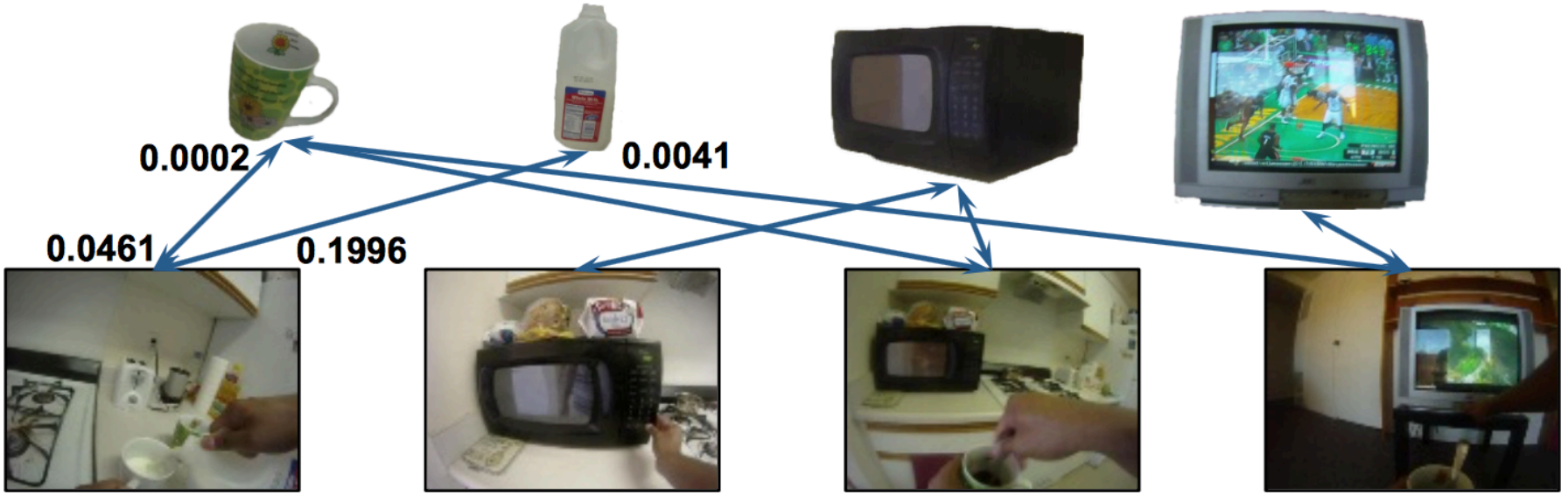


Figure from: Lu and Grauman (2013). Story-Driven Summarization for Egocentric Video. CVPR

Egocentric Video Summarisation

- Object-Driven

Figure from: Lu and Grauman (2013). Story-Driven Summarization for Egocentric Video. CVPR

Egocentric Video Summarisation

- Fixation-Driven with Constraints

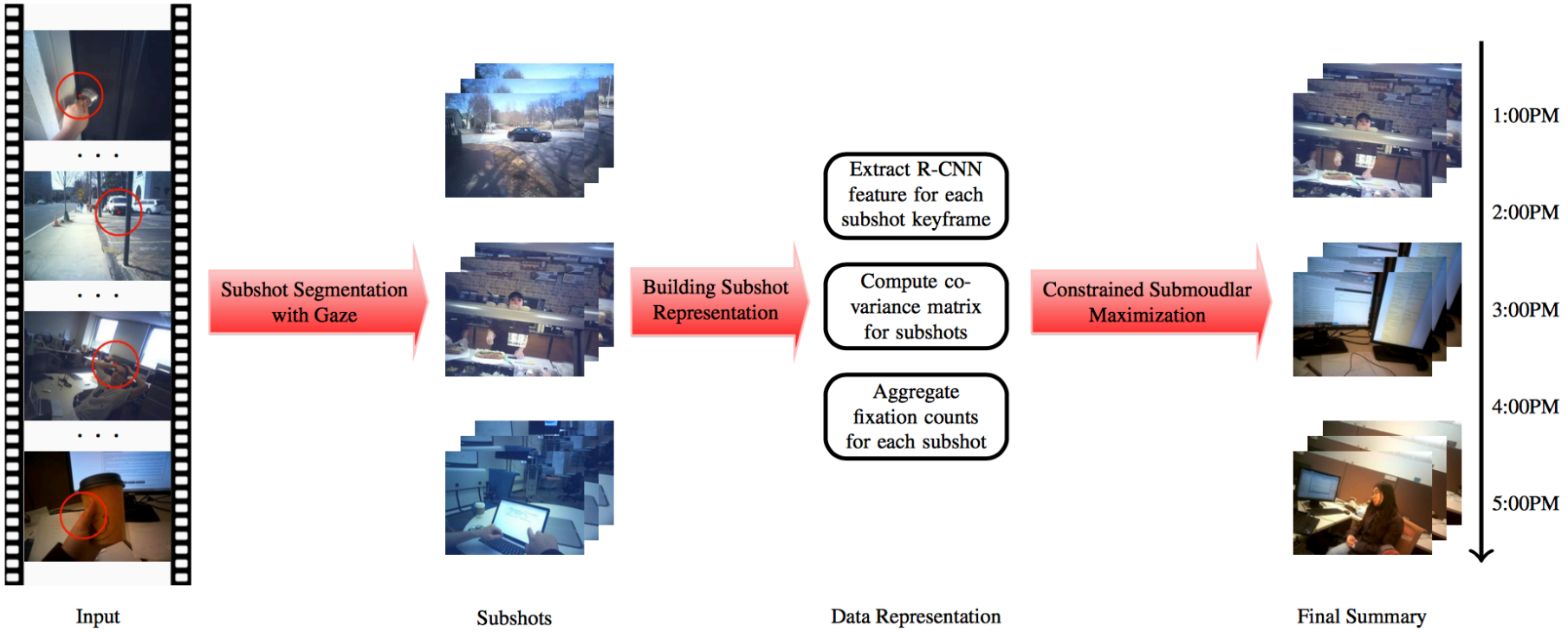
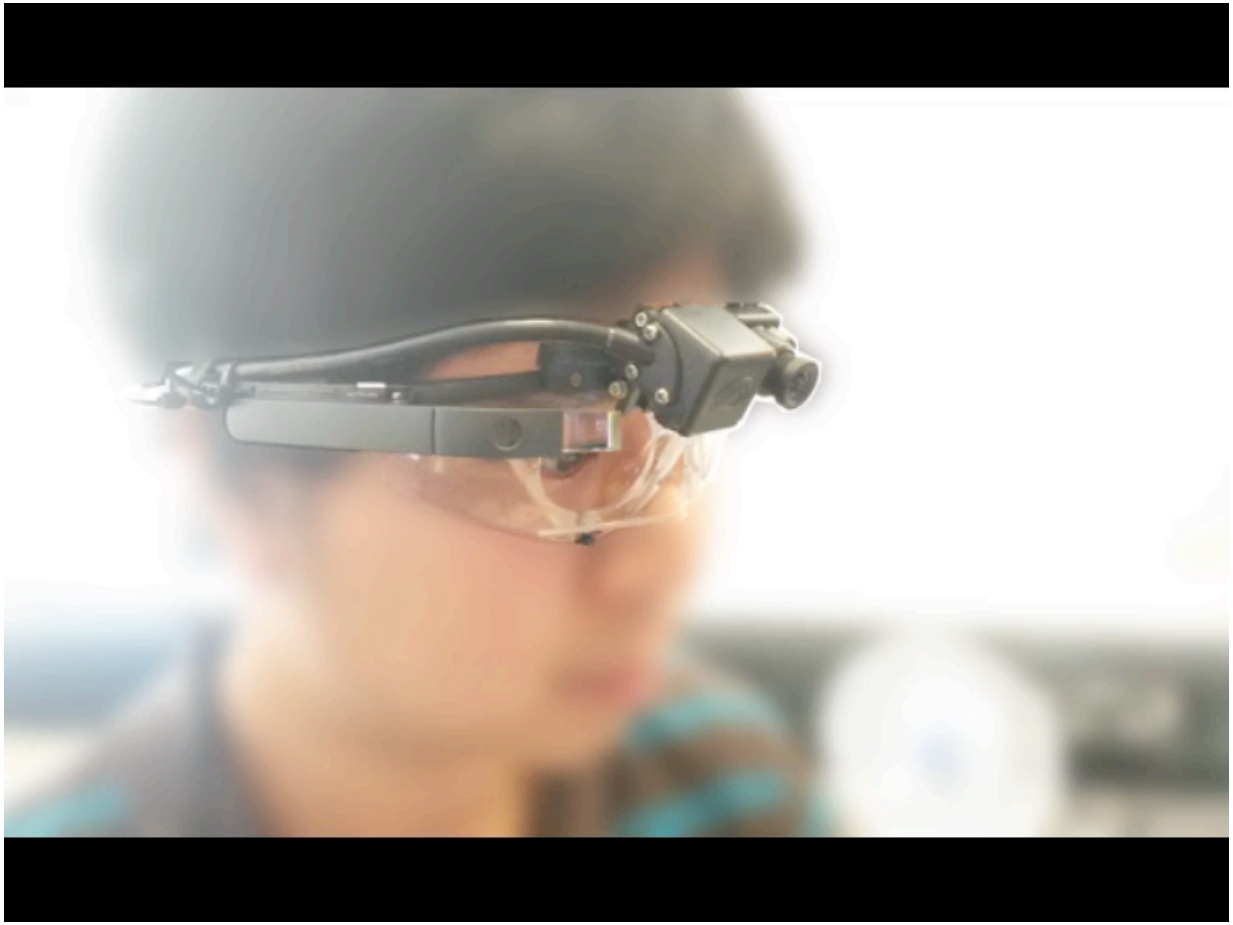


Figure from: Xu et al (2015). Gaze-enabled Egocentric Video Summarization via Constrained Submodular Maximization . CVPR

Egocentric Video Summarisation

- Fixations from IMUs



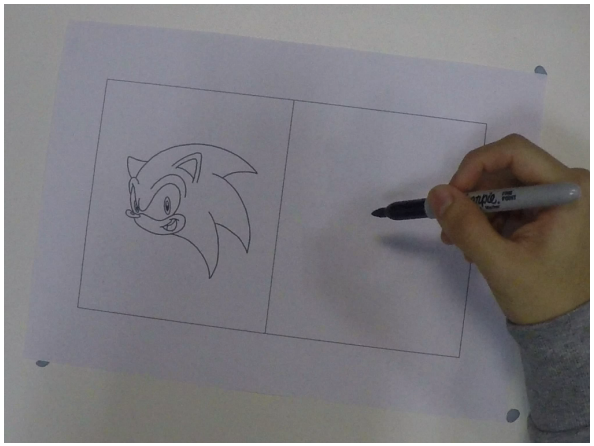
T Leelasawassuk, D Damen, W Mayol-Cuevas (2015). Estimating Visual Attention from a Head Mounted IMU. International Symposium on Wearable Computers (ISWC)

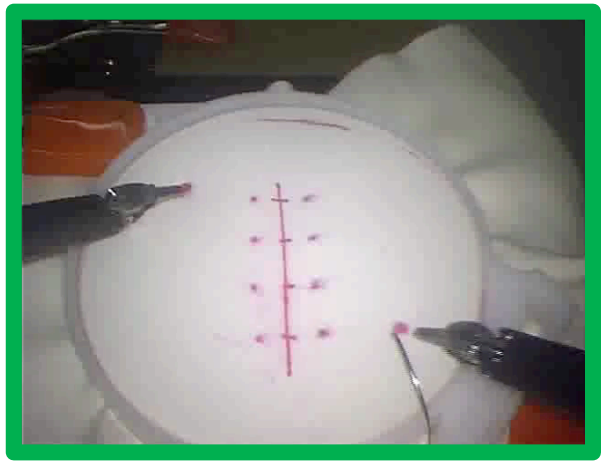
The Unique Applications

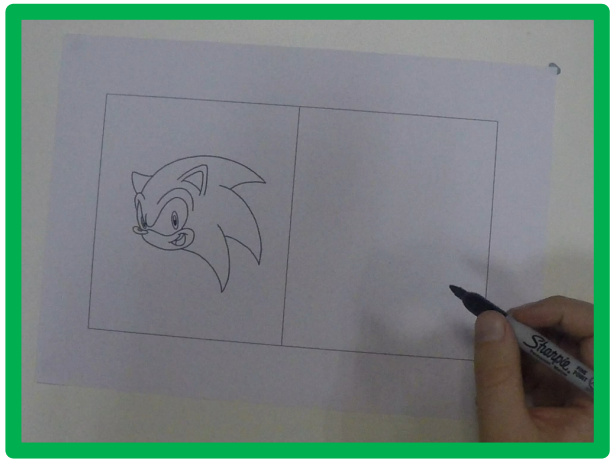
2. Skill Determination

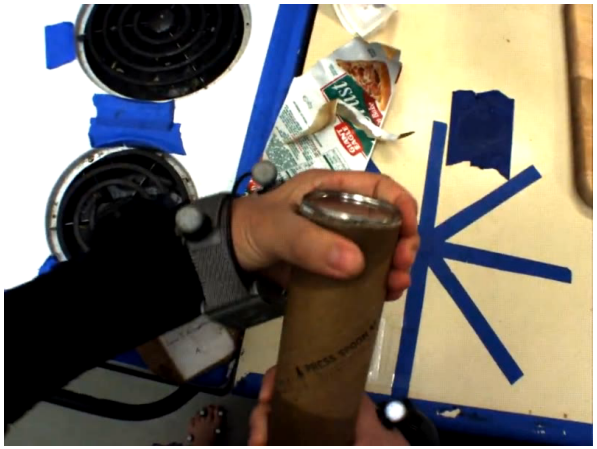
with: Hazel Doughty
Walterio Mayol-Cuevas

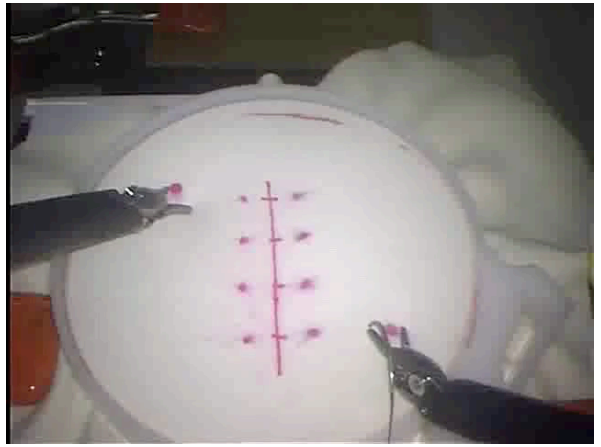
Who's Better?





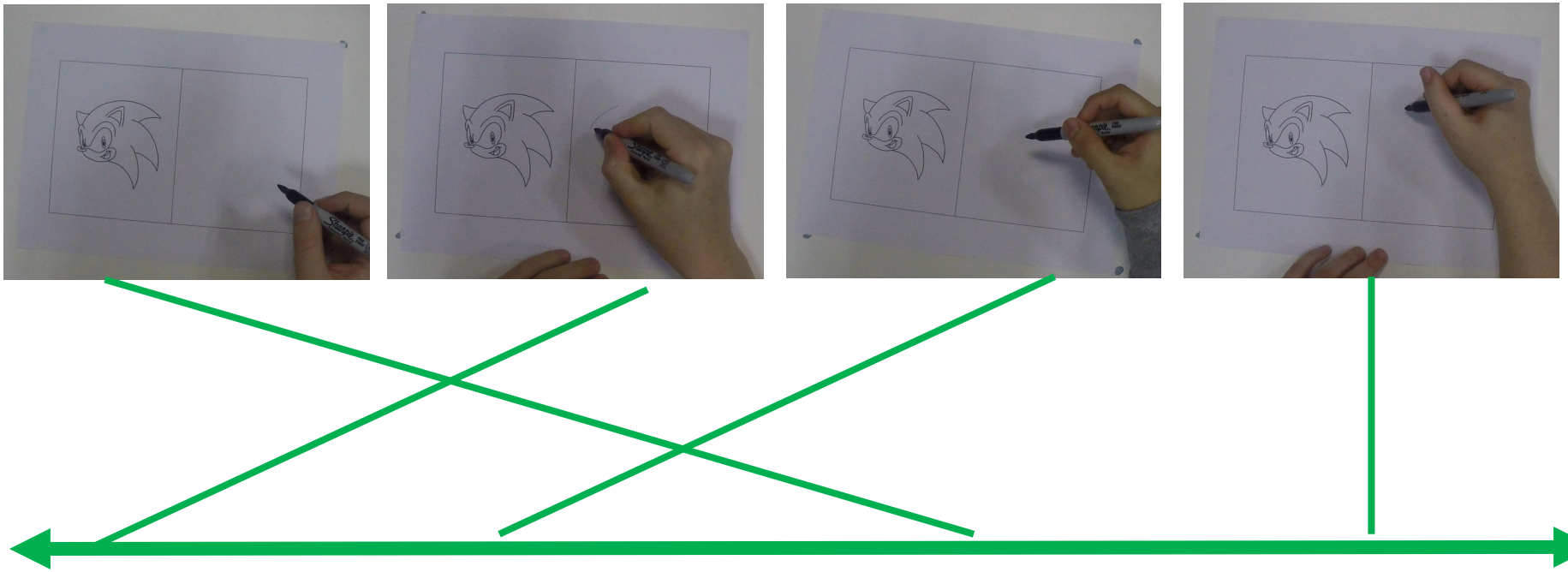






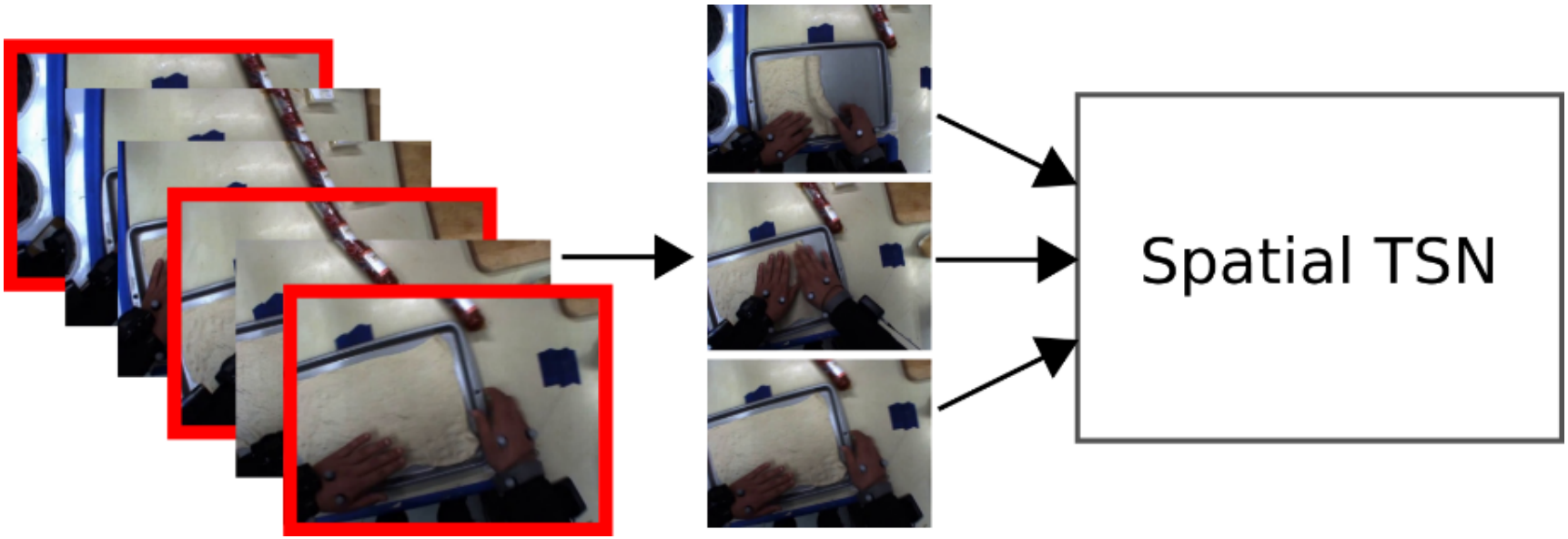
with: Hazel Doughty
Walterio Mayol-Cuevas

Who's Best?



Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

with: Hazel Doughty
Walterio Mayol-Cuevas



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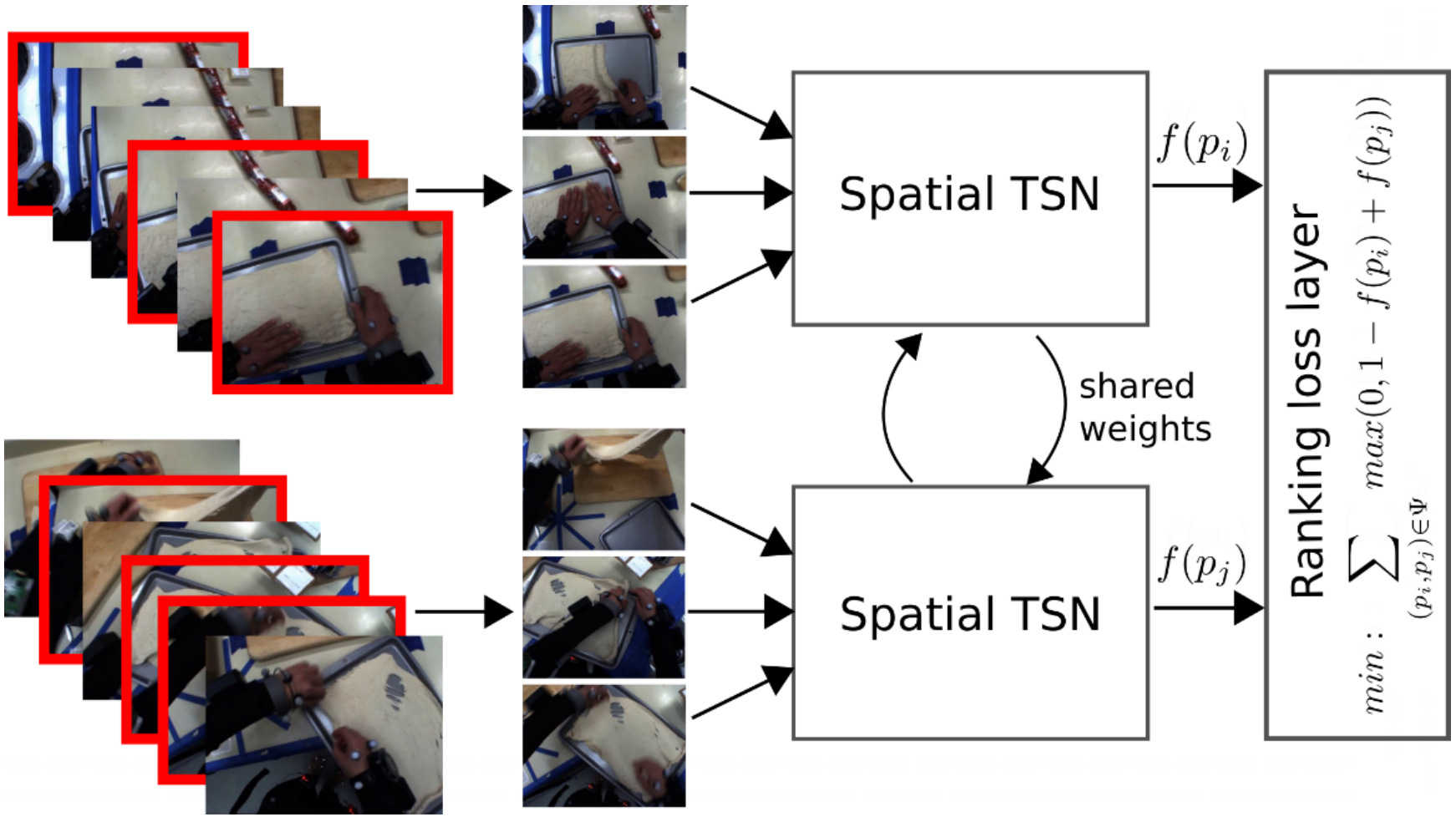

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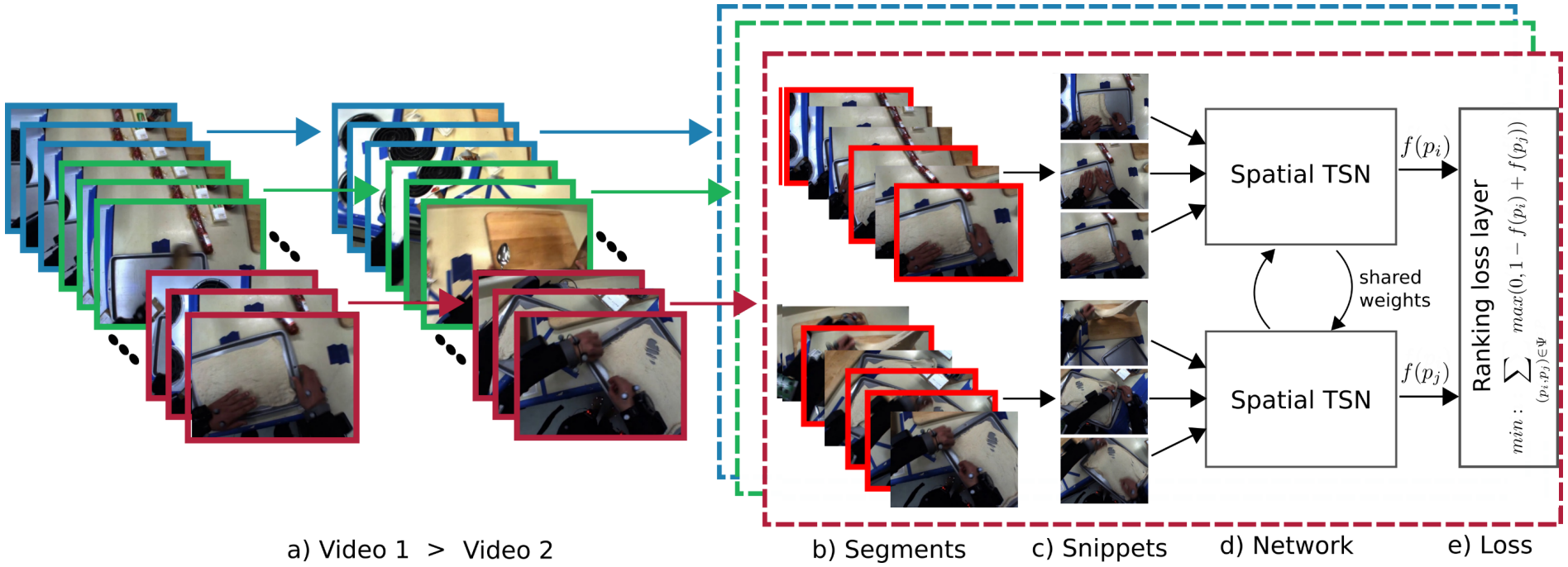
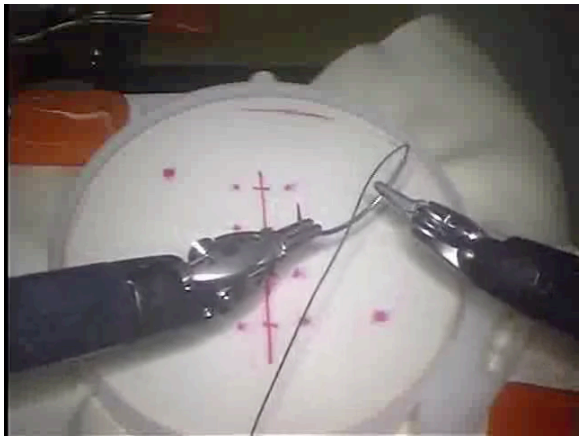


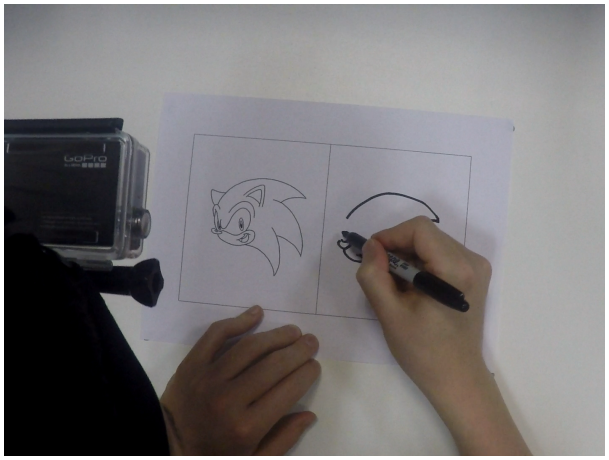
Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

with: Hazel Doughty
Walterio Mayol-Cuevas

Surgery[1]

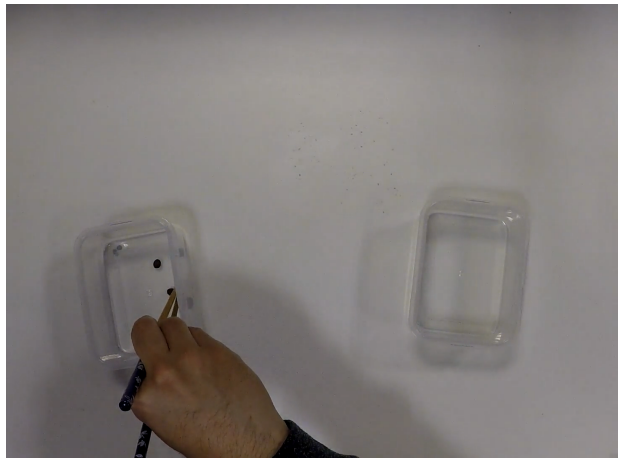


Drawing



Dough-Rolling[2]

Chopstick-Using



[1] Gao, Yixin, et al. "The JHU-ISI gesture and skill assessment dataset (JIGSAWS): A surgical activity working set for human motion modeling." Medical Image Computing and Computer-Assisted Intervention (MICCAI). 2014.

[2] De la Torre, Fernando, et al. "Guide to the carnegie mellon university multimodal activity (CMU-MMAC) database." *Robotics Institute* (2008): 135.

Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

with: Hazel Doughty
Walterio Mayol-Cuevas

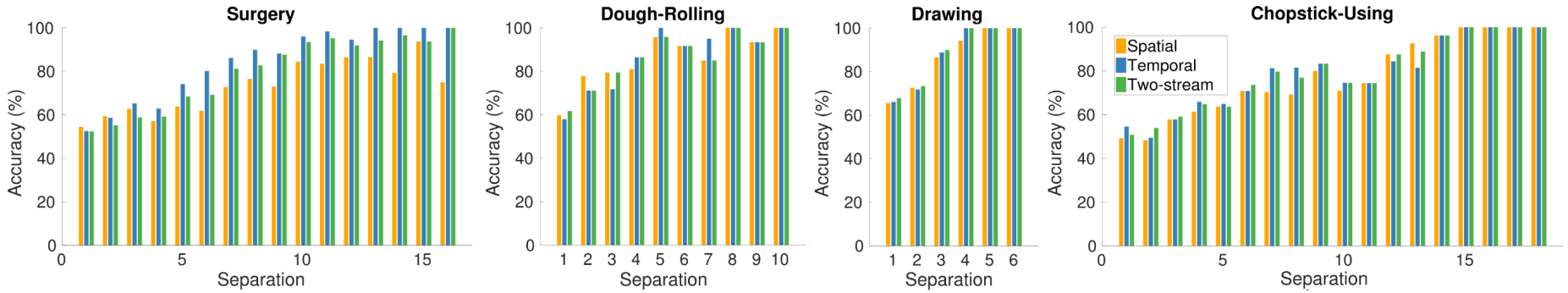
Task	Videos	Max Pairs	#Consistent Pairs	%Consistent Pairs
Surgery (Knot Tying)	36	630	596	95%
Surgery (Needle Passing)	28	378	362	96%
Surgery (Suturing)	39	741	701	95%
Dough-Rolling	33	528	181	34%
Drawing (Sonic)	20	190	118	62%
Drawing (Hand)	20	190	129	68%
Chopstick-Using	40	780	536	69%

[1] Gao, Yixin, et al. "The JHU-ISI gesture and skill assessment dataset (JIGSAWS): A surgical activity working set for human motion modeling." Medical Image Computing and Computer-Assisted Intervention (MICCAI). 2014.
[2] De la Torre, Fernando, et al. "Guide to the carnegie mellon university multimodal activity (CMU-MMAC) database." *Robotics Institute* (2008): 135.

Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

with: Hazel Doughty
Walterio Mayol-Cuevas

Task	Siamese TSN			Siamese TSN with data augmentation		
	Spatial	Temporal	Two-stream	Spatial	Temporal	Two-stream
Surgery	66.5%	**74.4%**	**74.4%**	66.5%	**75.3%**	**75.3%**
Dough-Rolling	73.9%	**76.7%**	75.4%	77.0%	76.1%	**78.2%**
Drawing	75.6%	76.5%	**77.4%**	76.7%	79.0%	**82.1%**
Chopstick-Using	67.7%	67.4%	**68.1%**	66.8%	69.8%	**70.0%**



Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

with: Hazel Doughty
Walterio Mayol-Cuevas

$$\frac{1}{\sigma}\sum_{j=1}^{\sigma} \alpha f_s\left(p_{ij}\right) + \left(1-\alpha\right) f_t\left(p_{ij}\right)$$

Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

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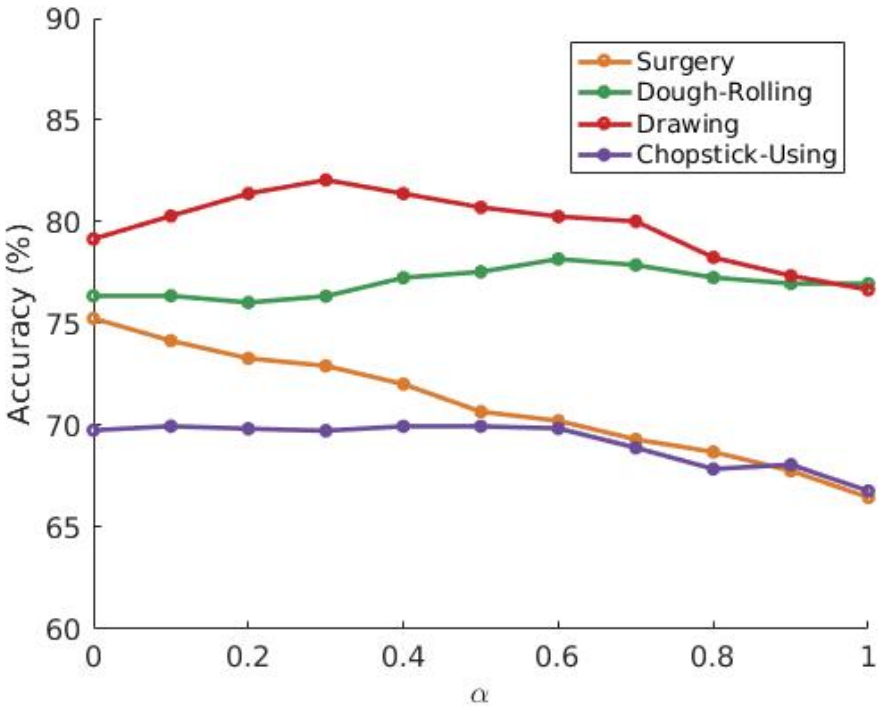
Walterio Mayol-Cuevas

$$\frac{1}{\sigma}\sum_{j=1}^{\sigma} \boldsymbol{\alpha} f_s(p_{ij}) + (1-\boldsymbol{\alpha}) f_t(p_{ij})$$



Who's Better? Who's Best? Skill Determination in Video using Deep Ranking

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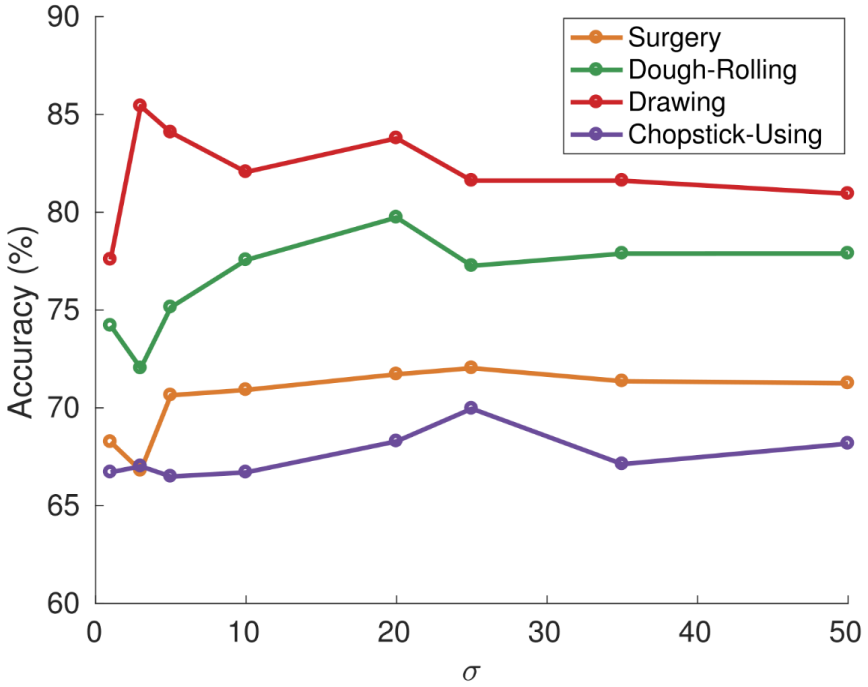
Walterio Mayol-Cuevas

$$\frac{1}{\boldsymbol{\sigma}}\sum_{j=1}^{\boldsymbol{\sigma}} \alpha f_s(p_{ij}) + (1-\alpha) f_t(p_{ij})$$



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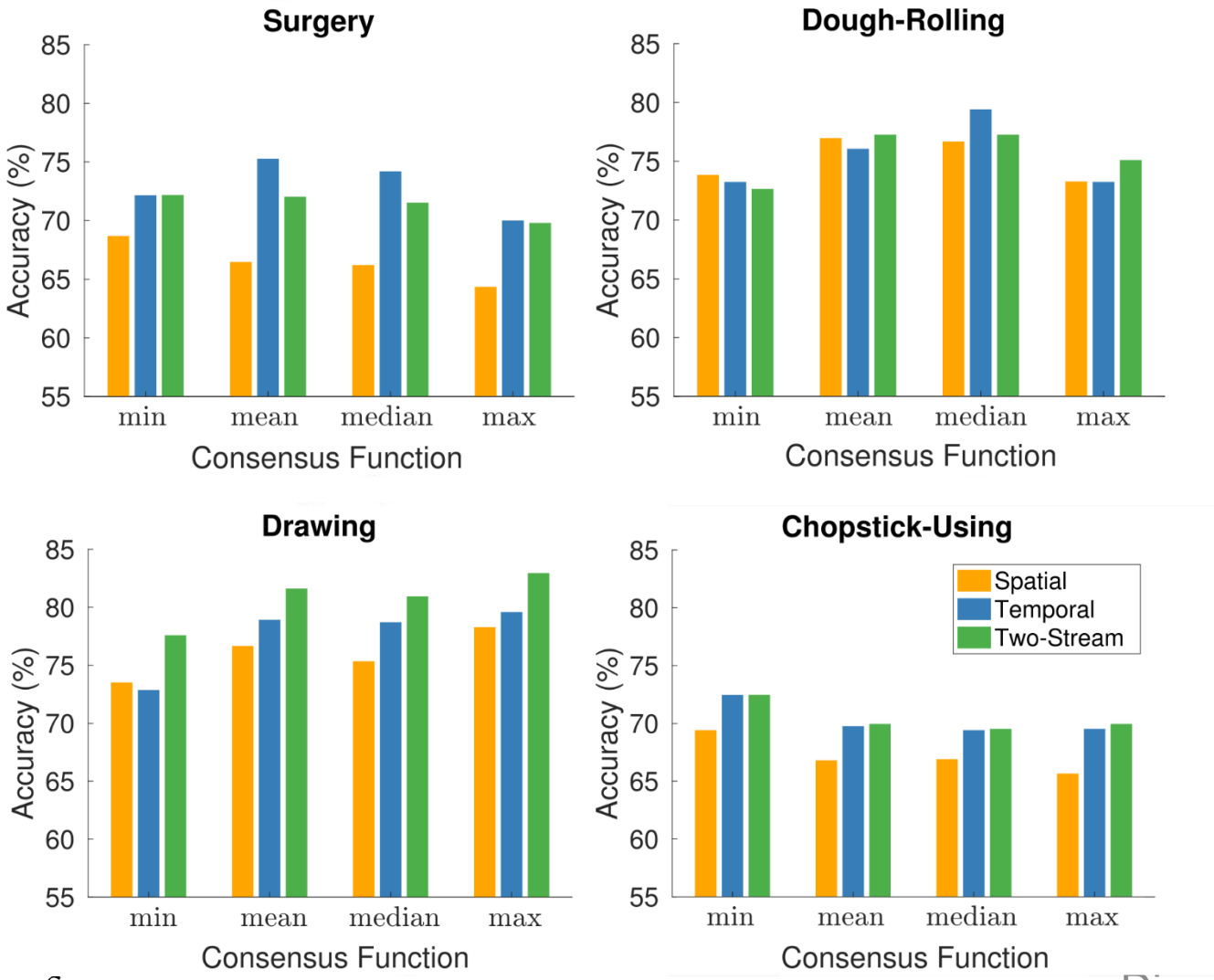
Walterio Mayol-Cuevas



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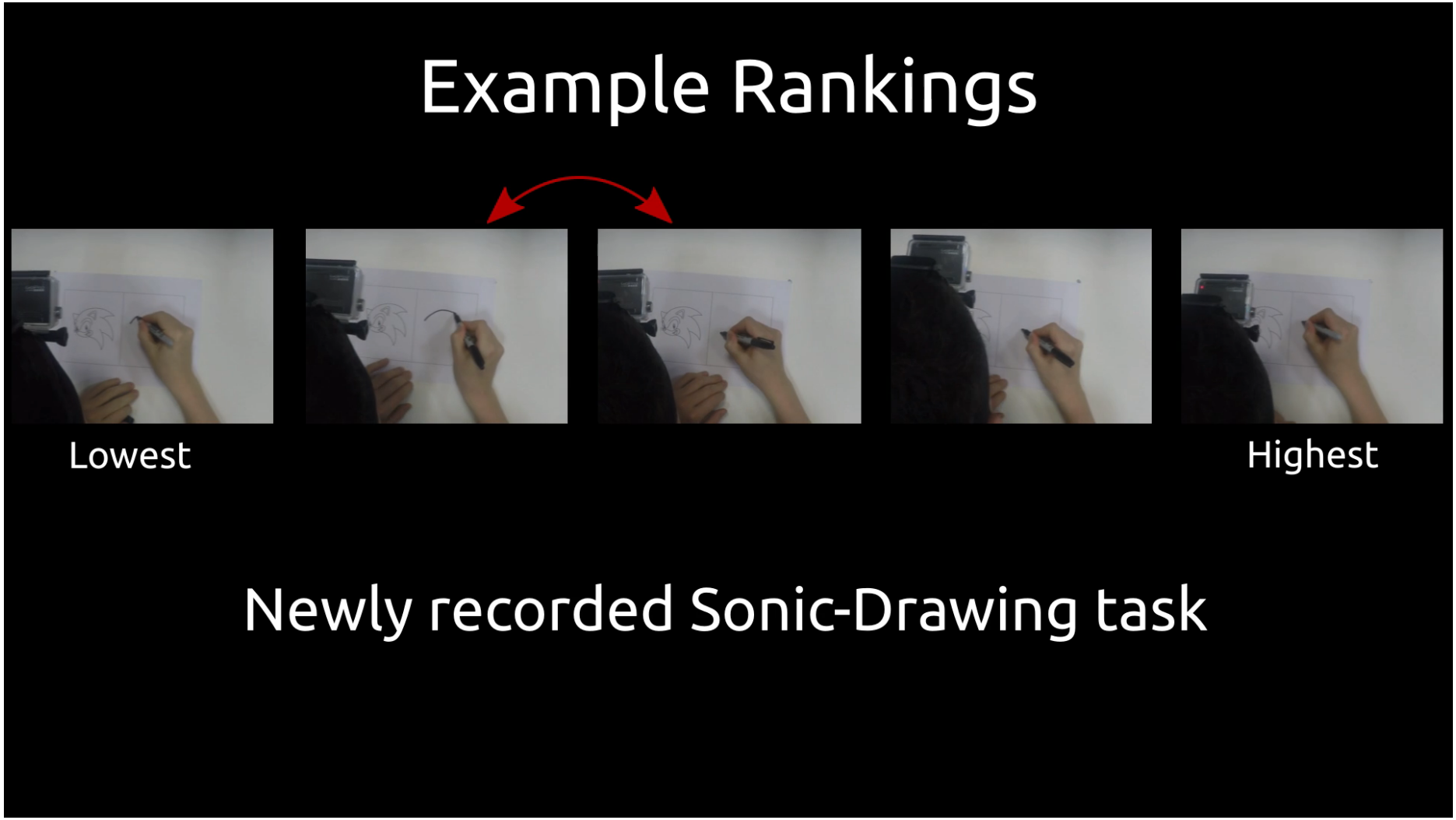
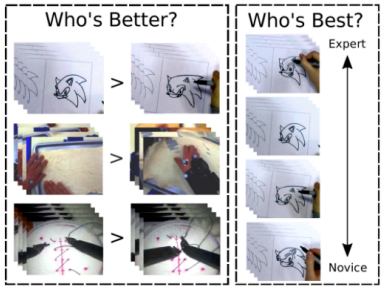


More info…

Project Who's Better, Who's Best: Skill Determination in Video



Video

Who's Better, Who's Best: Skill Determination in Video using Deep Ranking. H Doughty, D Damen, W Mayol-Cuevas. Arxiv (2017). PDF

The Unique Applications

3. Real-time Solutions

Wearable (Systems)!

- On-the-cloud processing
- On-the-mobile processing
- Onboard processing!

Connecting-to-the-cloud

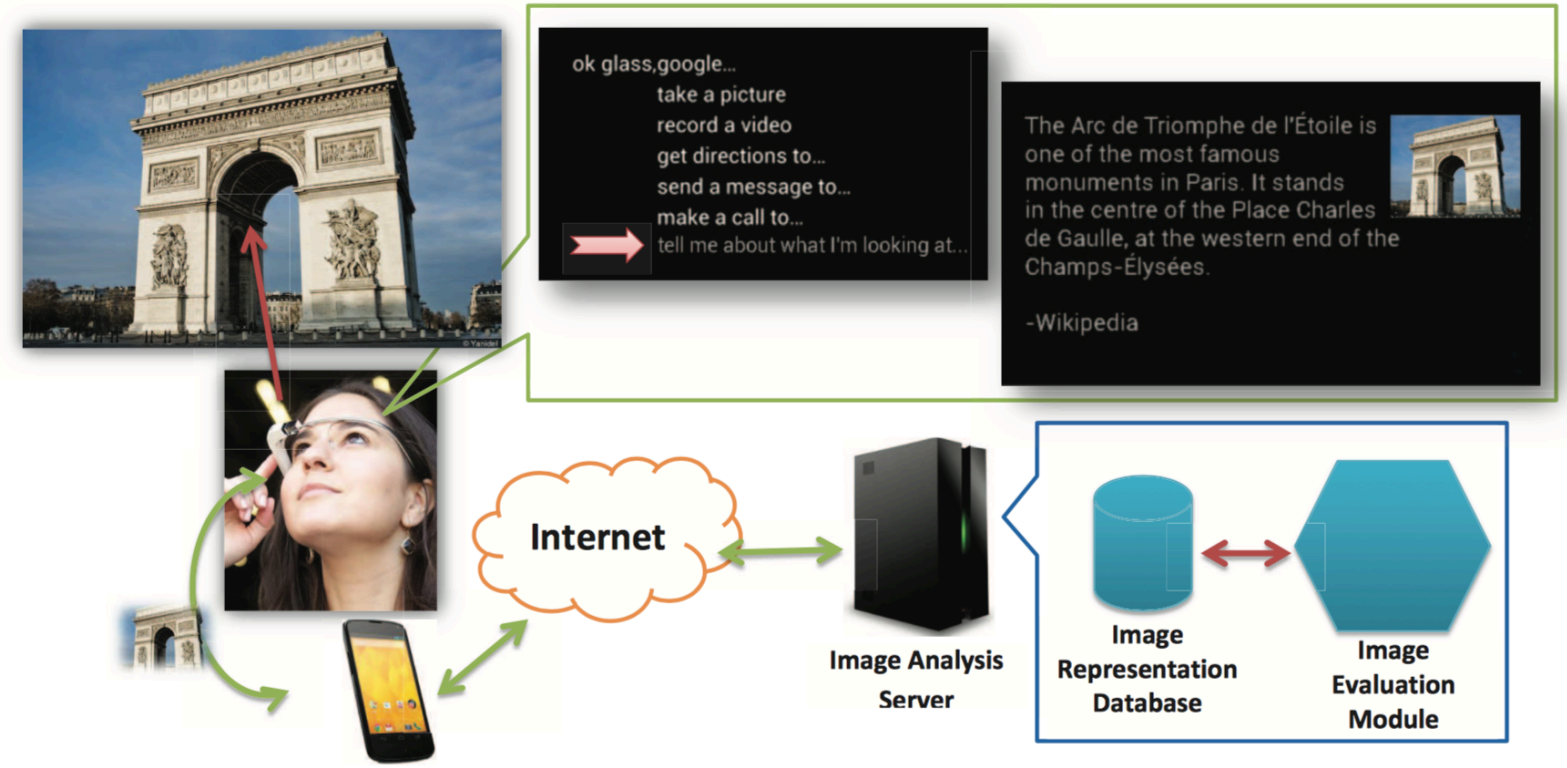


Figure 1. System overview. The user asks the device to inform her about her current view of Arc de Triomphe, and the system responds with the most relevant description in its database.

with: Walterio Mayol-Cuevas
Teesid Leelasawassuk

You Do, I Learn – Google Glass Prototype

D Damen, T Leelasawassuk, W Mayol-Cuevas (2016). You-Do, I-Learn: Egocentric Unsupervised Discovery of Objects and their Modes of Interaction Towards Video-Based Guidance. *Computer Vision and Image Understanding*

Interactive Conclusions

- Fill in the blanks:
  - Egocentric vision is ----------
  - Pick up an action (e.g. open door). Draw a sketch of how it looks like from FPV and TPV
  - The biggest challenge (in your opinion) in egocentric vision is ----------
  - The most interesting problem (to you) in egocentric vision is ----------

Interested in More?

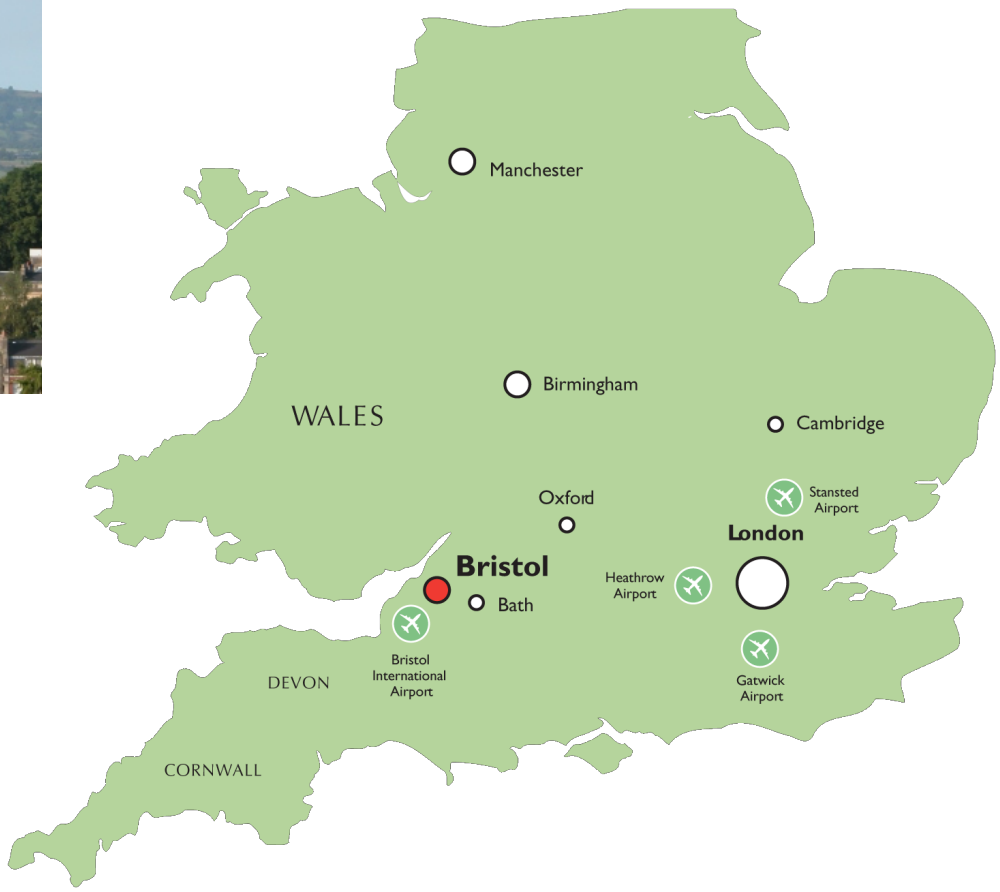
- Egocentric Perception, Interaction and Computing (EPIC) Workshop Series
  - ECCV 2016 (Amsterdam)
  - ICCV 2017 (Venice – this October)
    - Paper deadline expired
    - Abstract submission still open till Sep

Interested in More?

- Subscribe to the newly introduced mailing list: epic-community@bristol.ac.uk

- Instructions to subscribe:
  - send an email to: sympa@sympa.bristol.ac.uk
  - with the subject: **subscribe epic-community**
  - and blank message content

Bristol and University of Bristol



Bristol and University of Bristol

Thank you…

For further info, datasets, code, publications…

http://www.cs.bris.ac.uk/~damen

@dimadamen

http://www.linkedin.com/in/dimadamen