Human-centered computer vision in support of welfare

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Our mission…

Computer Vision

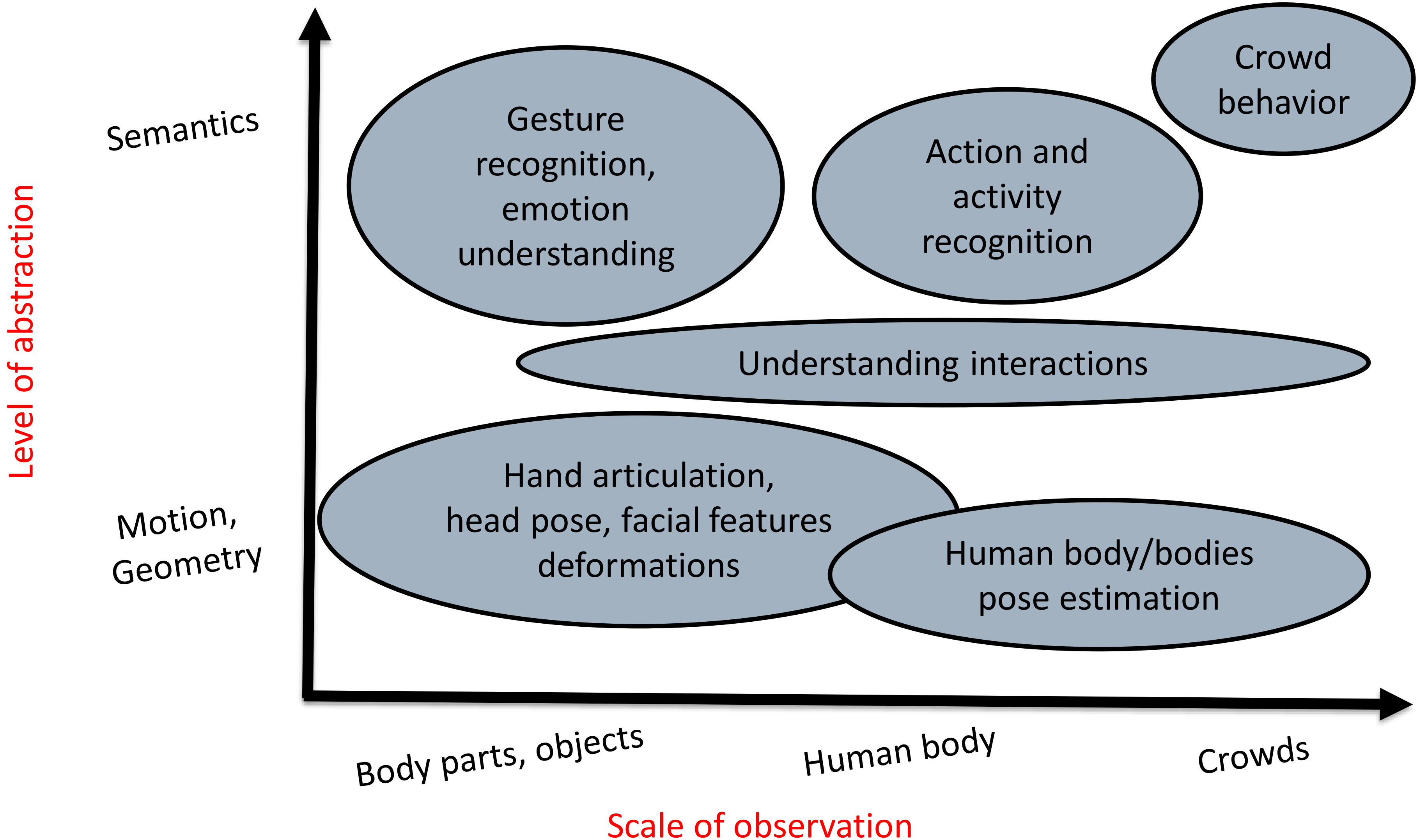
A branch of Artificial Intelligence that deals with the **development of technical systems with visual perception capabilities** that are based on the processing and analysis of images and videos

Human-Centered Computer Vision

Sensing and analysis of human presence in images and videos

Computational methods for **representing, perceiving and interpreting** aspects of **human presence** based on **visual information**

Our research landscape…



Our research landscape…

… actually, many more dimensions, i.e.:

Time dimension:

- What happened, what is happening now
- What is going to happen

Context dimension:

- In isolation
- In interaction with the environment

Are those interesting problems?

- **Theoretical interest**
  - Humans solve them, could technical systems solve them, too?
  - Solutions can probably prove useful in other, interesting, similar problems

- **Practical interest** in several application domains - cameras are everywhere!
  - Health/welfare
  - Safety/security/surveillance
  - Work, industrial automation
  - Transportation
  - Leisure/entertainment
  - …
  - Constrained only by human imagination…

Are those easy problems?

- Not really…
- Problems with high dimensionality…
- … that need to be solved based on relatively poor observations
  - Similar things may appear different
  - Different things may appear similar
  - Missing information (occlusions, etc)
  - Context-dependent interpretations
  - Variability in spatial scales
  - Variability in temporal scales
- Requirement for **physically plausible** solutions…

Indicative results

Emphasis on
“what” and **“why”**
rather than on **“how”**

Have a look at:

http://users.ics.forth.gr/~argyros/research.html

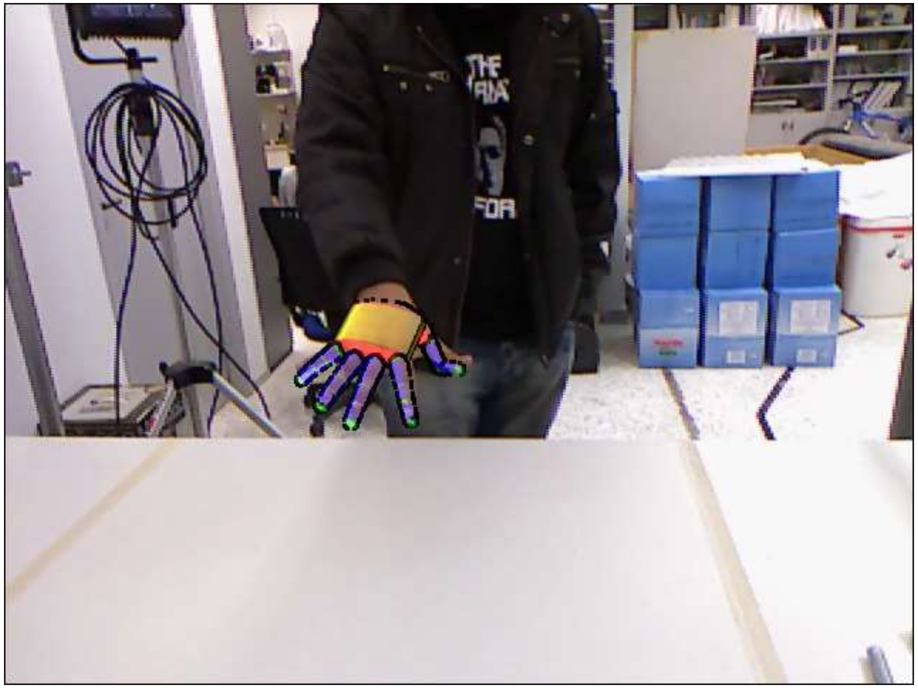
http://users.ics.forth.gr/~argyros/publications.html

http://www.youtube.com/AntonisArgyros

3D hand tracking based on RGB-D images

Physical plausibility:

– Respect anatomical constraints (hand dimensions, kinematic constraints, penalize interpenetration of hand parts)



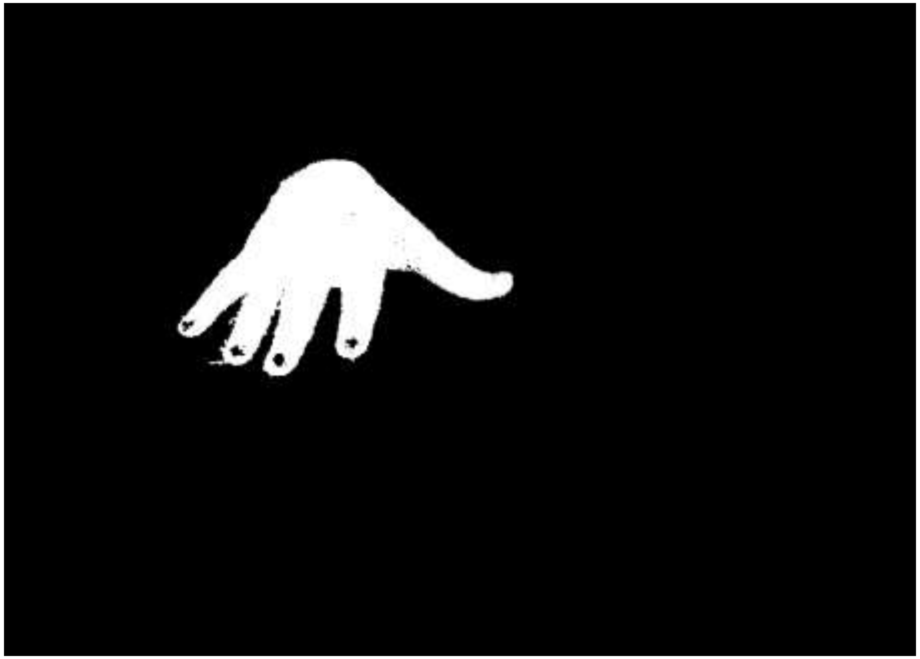
► I. Oikonomidis, N. Kyriazis and A.A. Argyros, **"Efficient model-based 3D tracking of hand articulations using Kinect"**, In *British Machine Vision Conference (BMVC 2011)*, BMVA, pp. 1-11, Dundee, UK, 2011. [DOI] [PDF] [URL] [VIDEO]

FORTH 3D Hand Tracking Library:

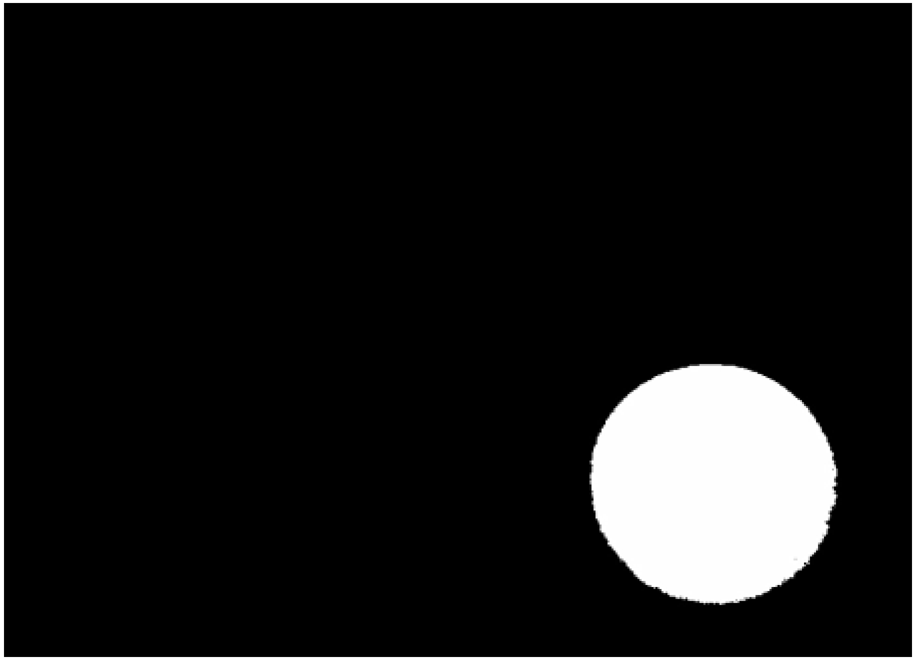
- **1st Prize, CHALEARN 2012 Gesture Recognition competition, Tsukuba, Japan, November 2012,** (collocated with ICPR'12, sponsored by Microsoft Research, USA)

A hand in interaction with an object

A key observation and idea:



Seeing the hand, "only"



Seeing the object, "only"

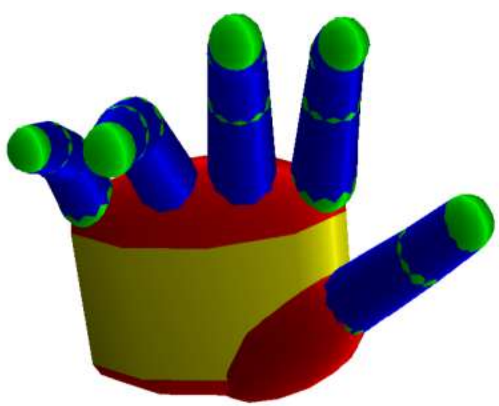
– Thus, occlusions due to hand-object interaction is not a curse to be bypassed but a feature to be exploited…

A hand in interaction with an object

Another (obvious, yet important) observation:

- A hand and an object cannot share the same physical space

- **Thus:**
  - Penalize physically implausible solutions (i.e., solutions that exhibit hand-object interpenetration)



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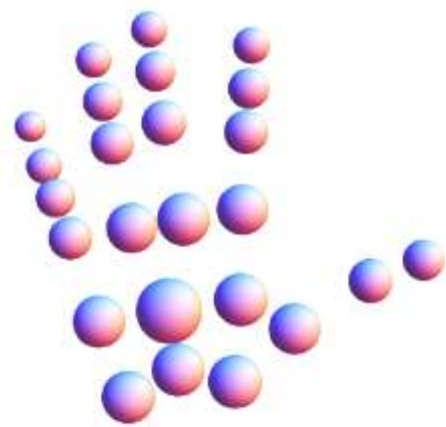
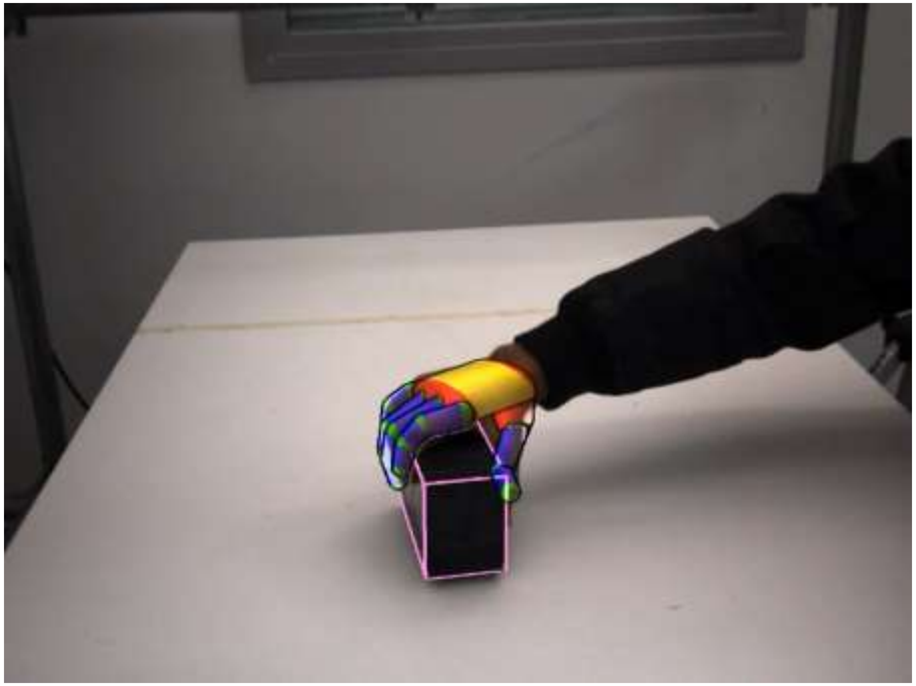
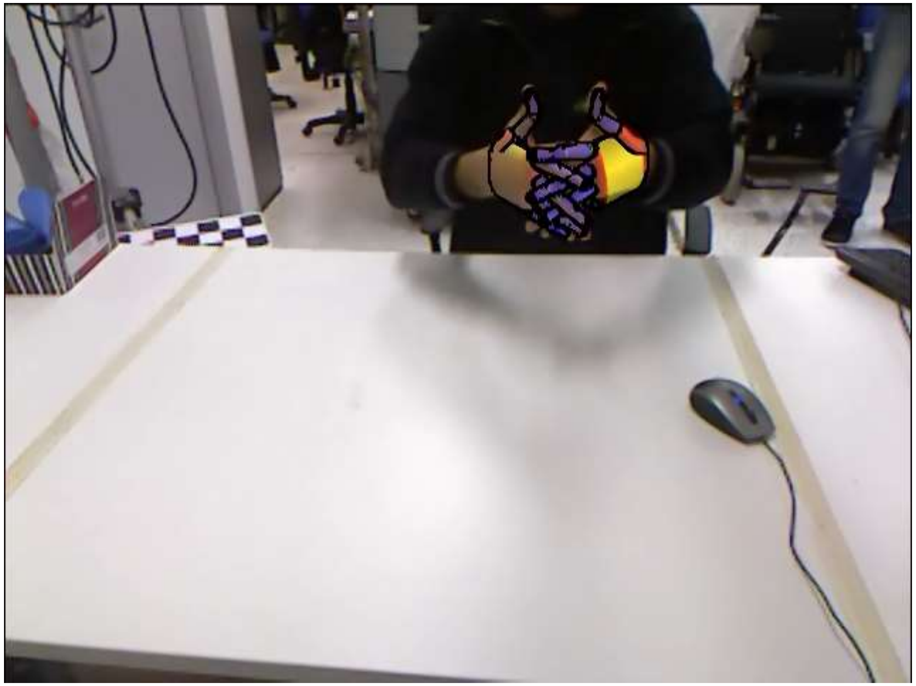


A hand in interaction with an object





► I. Oikonomidis, N. Kyriazis and A.A. Argyros, **"Full DOF tracking of a hand interacting with an object by modeling occlusions and physical constraints"**, In *IEEE International Conference on Computer Vision (ICCV 2011)*, IEEE, pp. 2088-2095, Barcelona, Spain, November 2011. [DOI] [PDF] [URL] [VIDEO]

► I. Oikonomidis, N. Kyriazis and A.A. Argyros, **"Tracking the articulated motion of two strongly interacting hands"**, In *IEEE Computer Vision and Pattern Recognition (CVPR 2012)*, IEEE, pp. 1862-1869, Providence, Rhode Island, USA, June 2012. [DOI] [PDF] [URL] [VIDEO]

On the physical plausibility of the solutions

- Solutions are plausible with respect to
  - Hand model parameters (anatomical validity, kinematic constraints)
  - No hand/hand – hand-object penetration
- More physical constraints can be taken into account, but one needs to consider them one-by-one…

Physically plausible 3D scene tracking: The single actor hypothesis

- **Our approach:**
  Search for the **hand motion**, that, in a **physics based simulation** environment, results in hand-object configurations that are as similar as possible to actual, RGBD-camera-based observations…
- … thus, given
  - physics-based simulation of hand motion ***x*,**
  - physics-based simulator ***S*,**
  - observations ***O*** and objective function ***E***
- scene tracking amounts to solving:

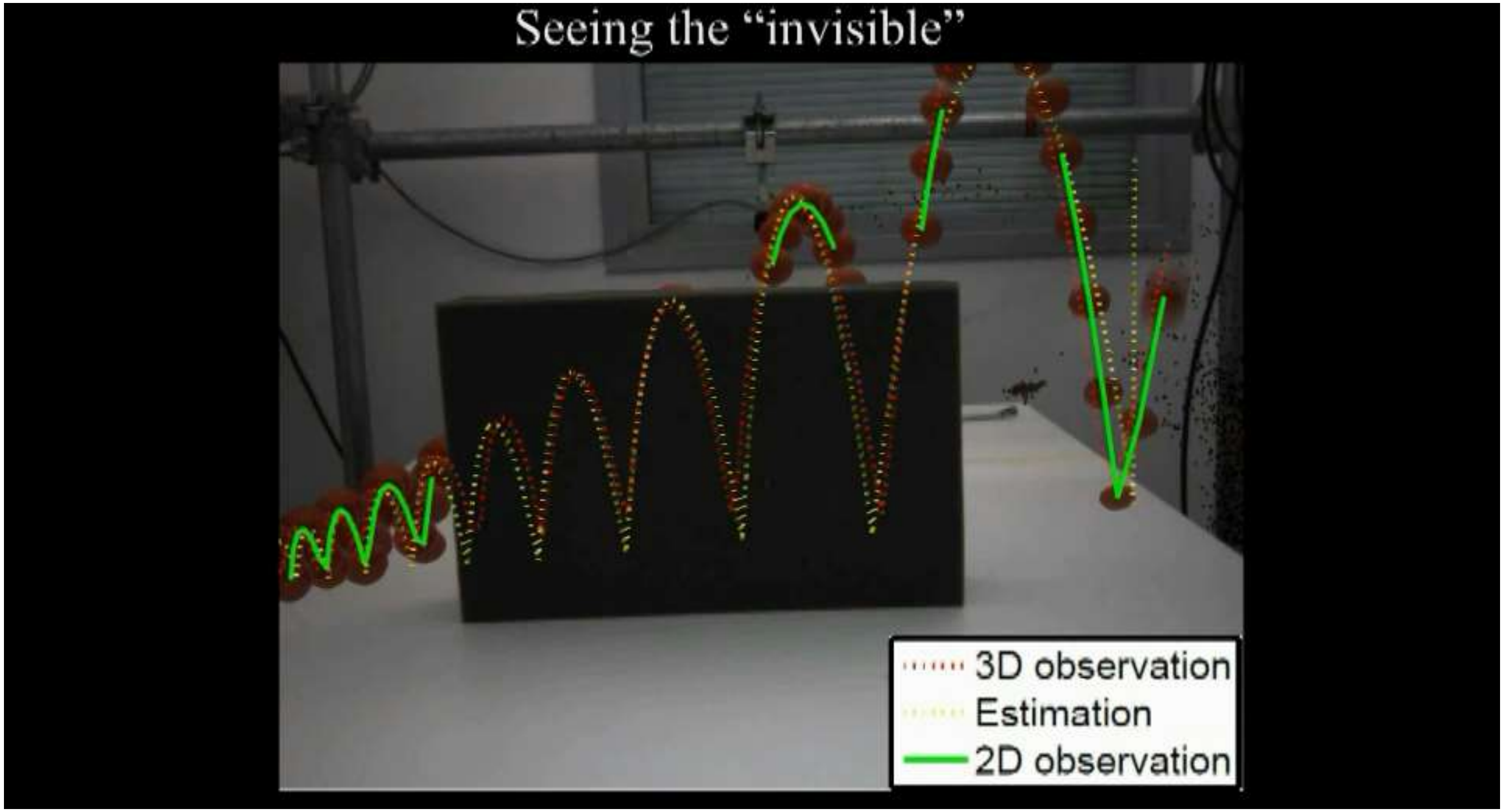
$$x^* \overset{PSO}{=} \arg\min_x \{E(O, S(x))\}$$

More hand-object interaction…

► N. Kyriazis and A.A. Argyros, **"Physically Plausible 3D Scene Tracking: The Single Actor Hypothesis"**, In *IEEE Computer Vision and Pattern Recognition (CVPR 2013)*, IEEE, pp. 9-16, Portland, Oregon, USA, June 2013. [DOI] [PDF] [URL] [VIDEO]

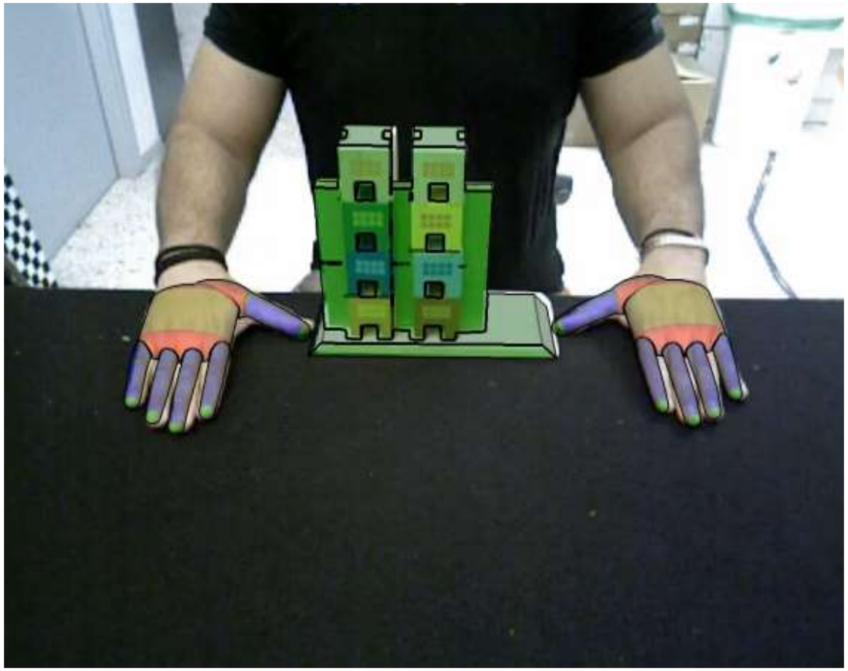
Physically plausible motion estimation of objects

Seeing through walls



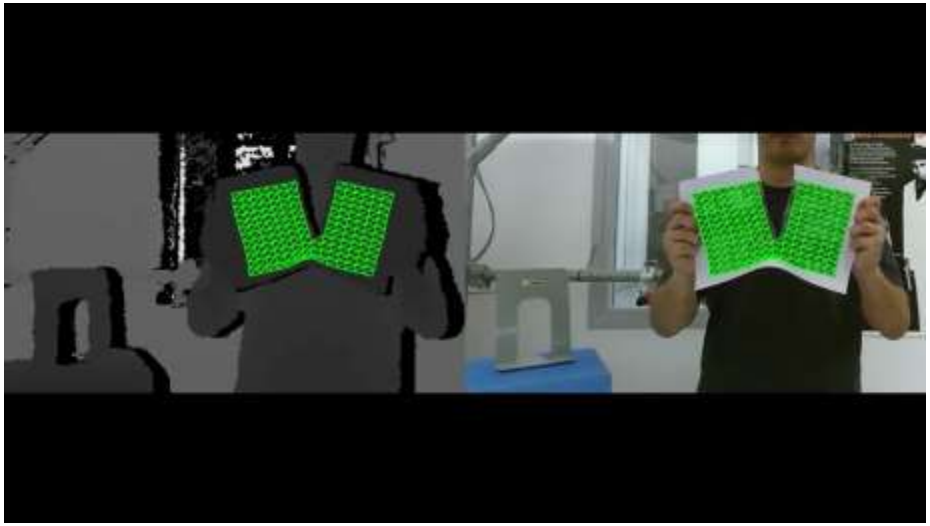
► N. Kyriazis, I. Oikonomidis and A.A. Argyros, **"Binding Computer Vision to Physics Based Simulation: The Case Study of a Bouncing Ball"**, In *British Machine Vision Conference (BMVC 2011)*, BMVA, pp. 1-11, Dundee, UK, 2011. [DOI] [PDF] [URL] [VIDEO]

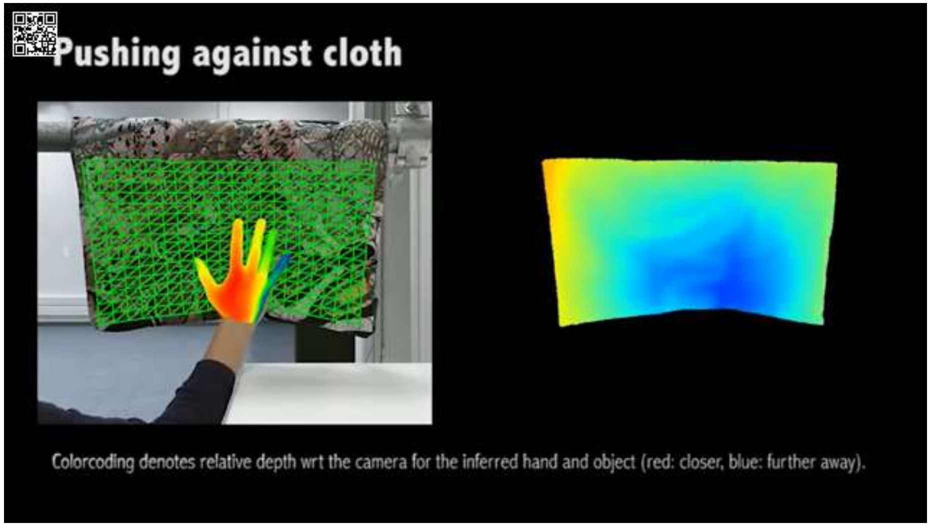
More hand-object interaction…



► N. Kyriazis and A.A. Argyros, **"Scalable 3D Tracking of Multiple Interacting Objects"**, In *IEEE Computer Vision and Pattern Recognition (CVPR 2014)*, IEEE, pp. 3430-3437, Columbus, Ohio, USA, June 2014.
[DOI] [PDF] [URL] [VIDEO]

Joint 3D tracking of a deformable object in interaction with a hand

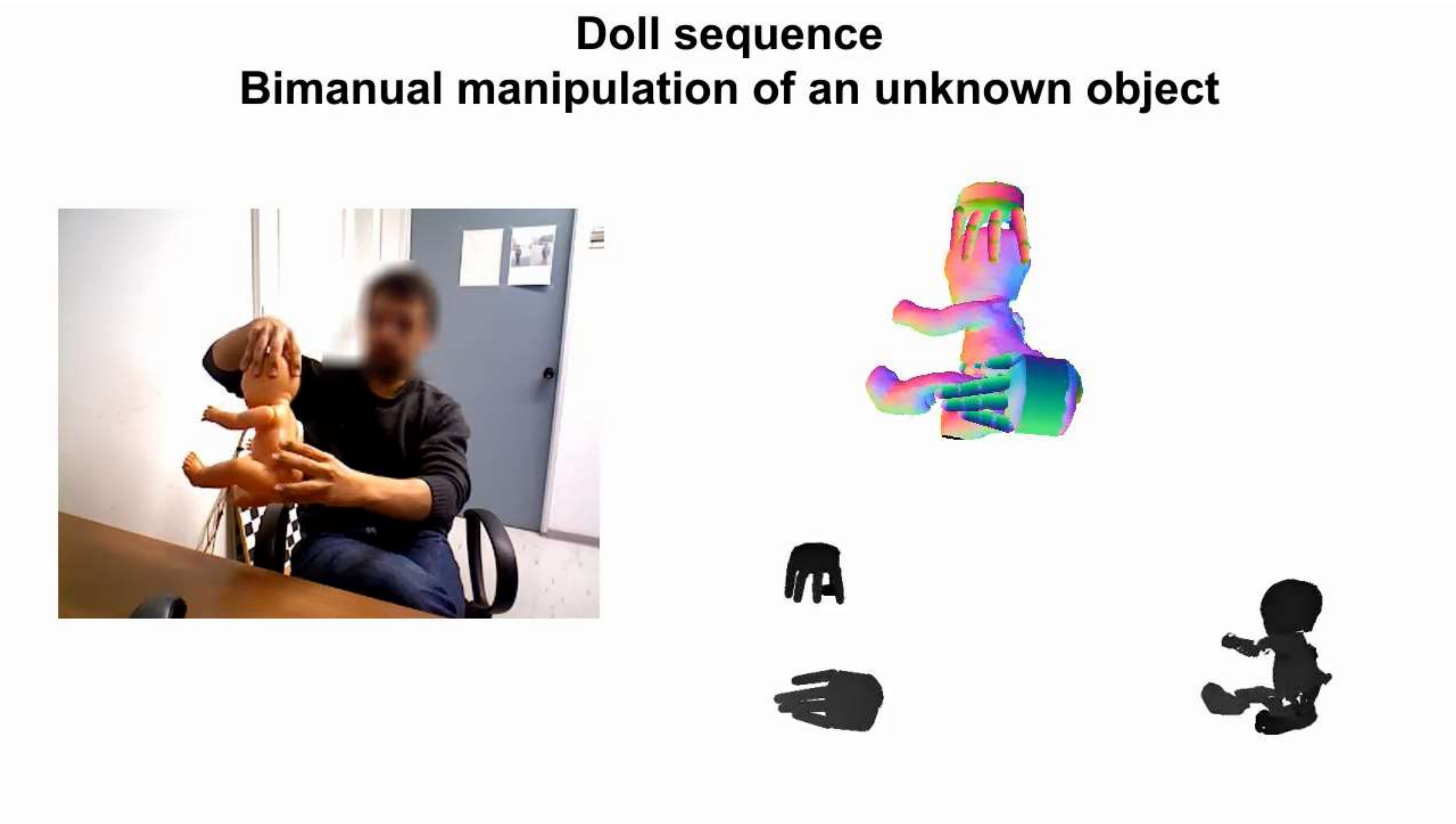




► A. Tsoli and A.A. Argyros, **"Tracking deformable surfaces that undergo topological changes using an RGB-D camera"**, In *International Conference on 3D Vision (3DV 2016)*, pp. 333-341, Stanford University, California, USA, October 2016. [DOI] [PDF] [URL] [VIDEO]

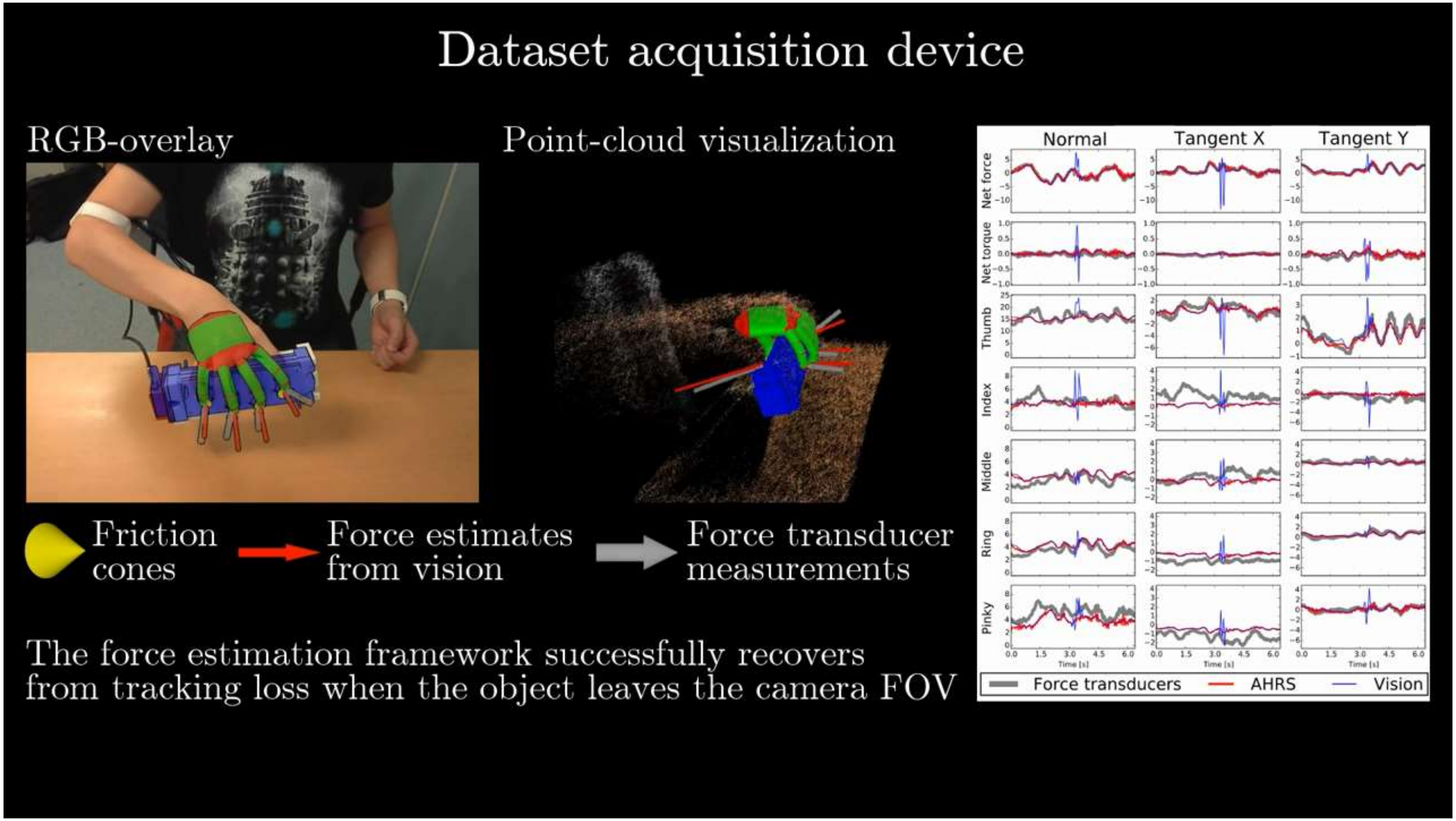
► A. Tsoli and A.A. Argyros, **"Joint 3D tracking of a deformable object in interaction with a hand"**, In *European Conference on Computer Vision (ECCV 2018) (to appear)*, Springer, September 2018. [PDF] [URL] [VIDEO]

3D tracking of hands in interaction with unknown objects



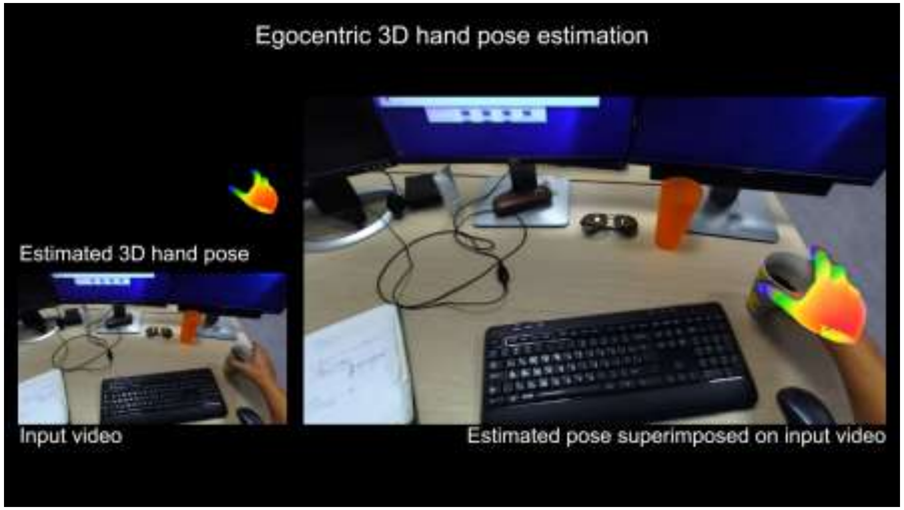
► P. Panteleris, N. Kyriazis and A.A. Argyros, **"3D Tracking of Human Hands in Interaction with Unknown Objects"**, In *British Machine Vision Conference (BMVC 2015)*, BMVA, pp. 123-1, Swansea, UK, September 2015. [DOI] [PDF] [URL] [VIDEO]

Force Sensing from Vision (FSV)



►T.-H. Pham, N. Kyriazis, A.A. Argyros and A. Kheddar, **"Hand-Object Contact Force Estimation From Markerless Visual Tracking",** *IEEE Transactions on Pattern Analysis and Machine Intelligence*, IEEE, October 2017. [DOI] [PDF] [URL] [VIDEO]

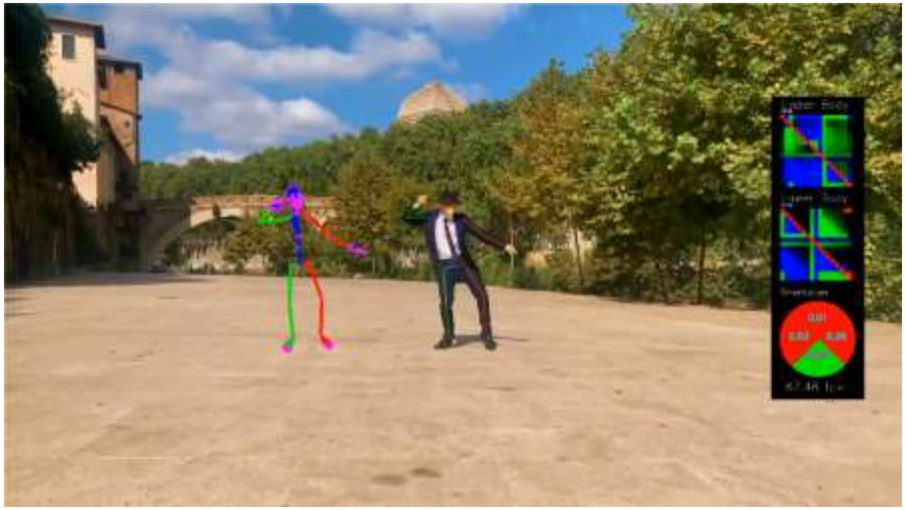
3D tracking of hands and human body parts based on monocular RGB



- Requires a **single RGB camera**
  - Less constraints on spatial resolution, temporal resolution, distance from the camera, illumination conditions, exploitable camera setups
- Auto-initialization, single frame 3D pose estimation → **no drift**

► P. Panteleris, I. Oikonomidis and A.A. Argyros, **"Using a single RGB frame for real time 3D hand pose estimation in the wild"**, In *IEEE Winter Conference on Applications of Computer Vision (WACV 2018), also available at arxiv.*, IEEE, pp. 436-445, lake Tahoe, NV, USA, March 2018. [DOI] [PDF] [URL] [VIDEO]

3D human body tracking



Single RGBD camera

► D. Michel and A.A. Argyros, **"Apparatuses, methods and systems for recovering a 3-dimensional skeletal model of the human body"**, United States Patent No 20160086350, Filed: 22 September, 2015, Published: 24 March, 2016. [DOI] [PDF] [URL] [VIDEO]

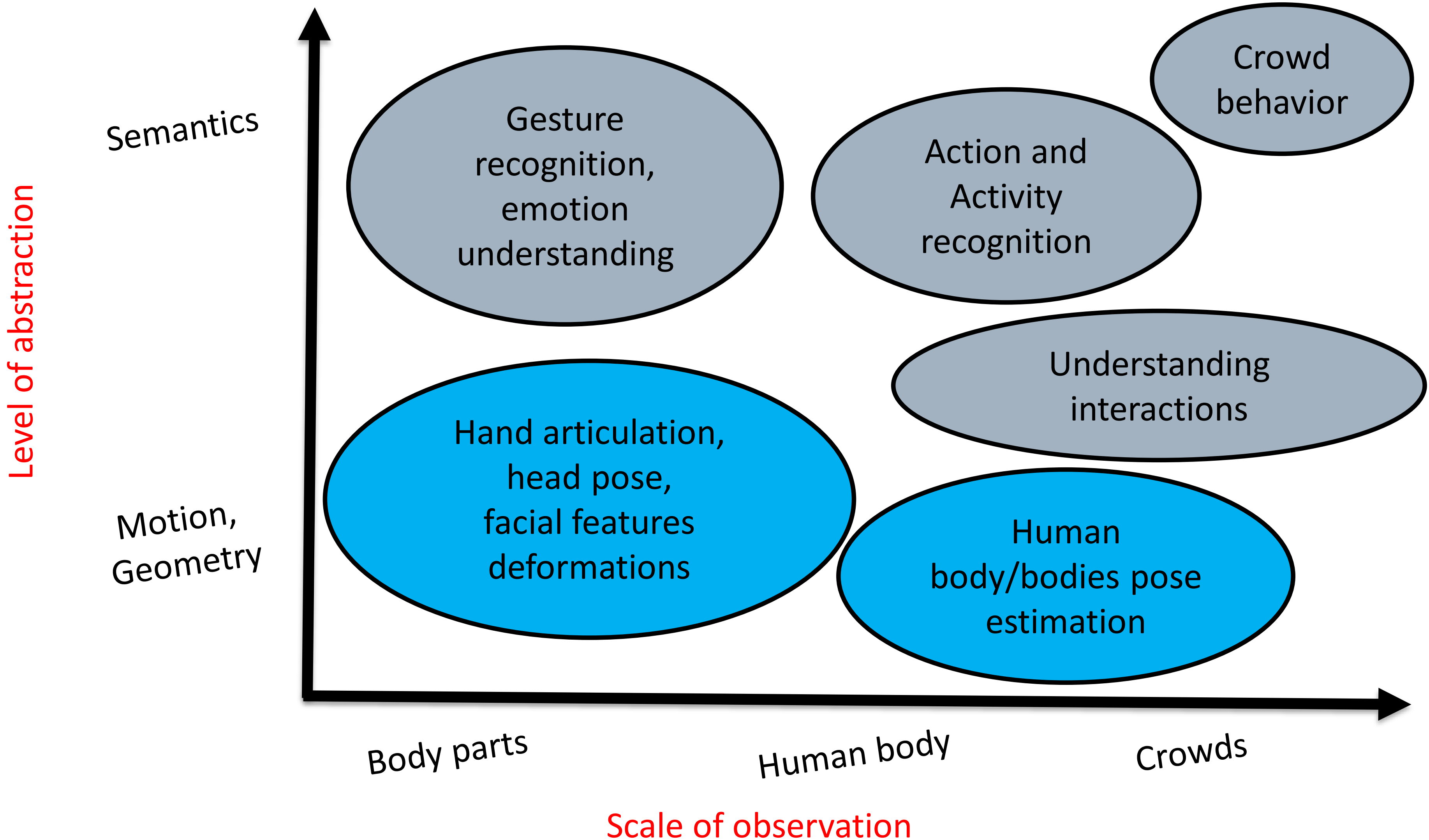
► D. Michel, A. Qammaz and A.A. Argyros, **"Markerless 3D Human Pose Estimation and Tracking based on RGBD Cameras: an Experimental Evaluation"**, In *International Conference on Pervasive Technologies Related to Assistive Environments (PETRA 2017)*, ACM, pp. 115-122, Rhodes, Greece, June 2017. [DOI] [PDF] [URL] [VIDEO]

Single RGB camera

► A. Qammaz and A.A. Argyros, **"MocapNET: Ensemble of SNN Encoders for 3D Human Pose Estimation in RGB Images"**, In *British Machine Vision Conference (BMVC 2019) (to appear)*, BMVA, Cardiff, UK, September 2019. [PDF] [URL] [VIDEO]

► A. Qammaz and A.A. Argyros, **"Occlusion-tolerant and personalized 3D human pose estimation in RGB images"**, In *IEEE International Conference on Pattern Recognition (ICPR 2020), (to appear)*, January 2021. [PDF] [URL] [VIDEO]

We have seen indicative results mostly in:



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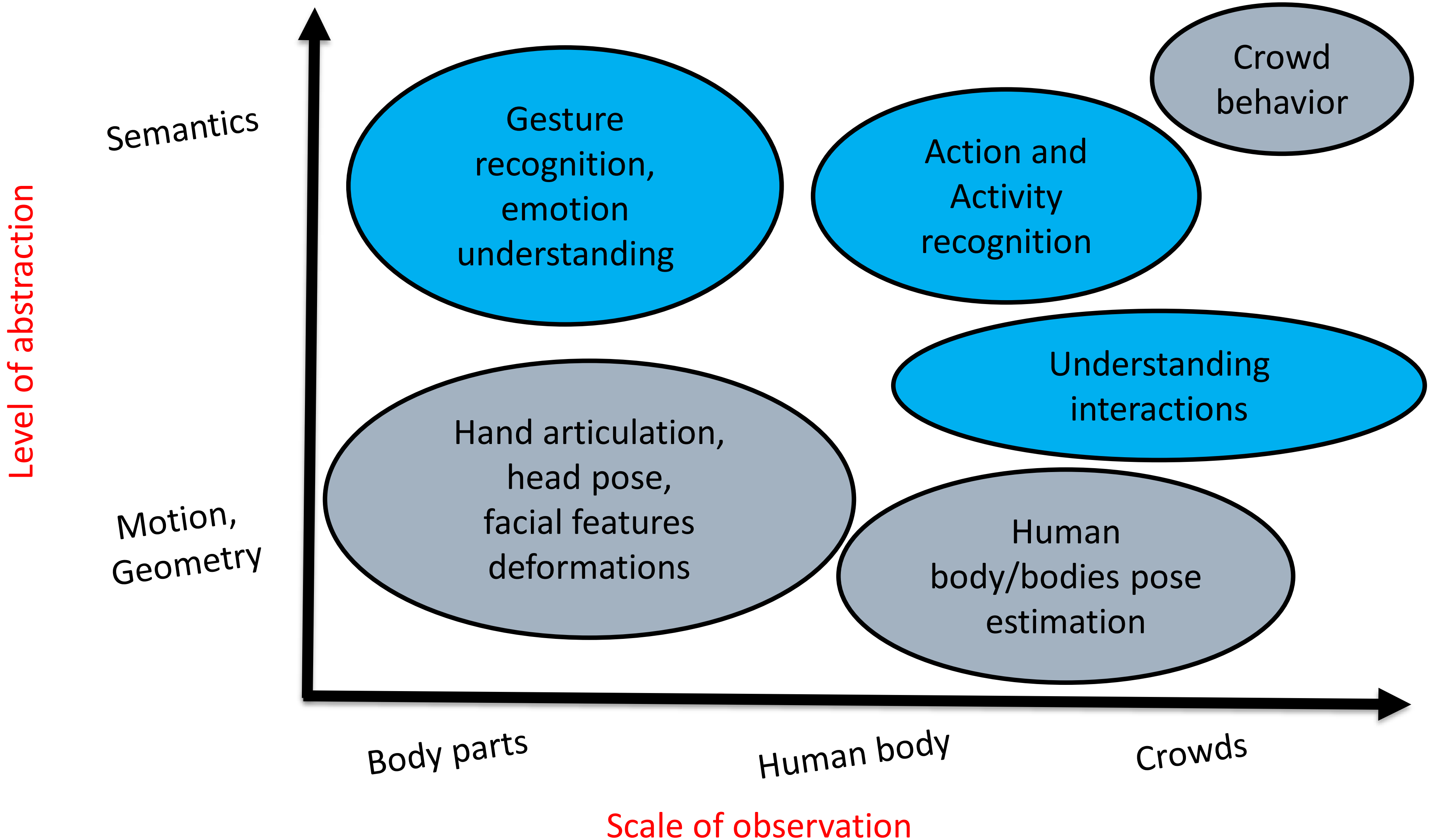
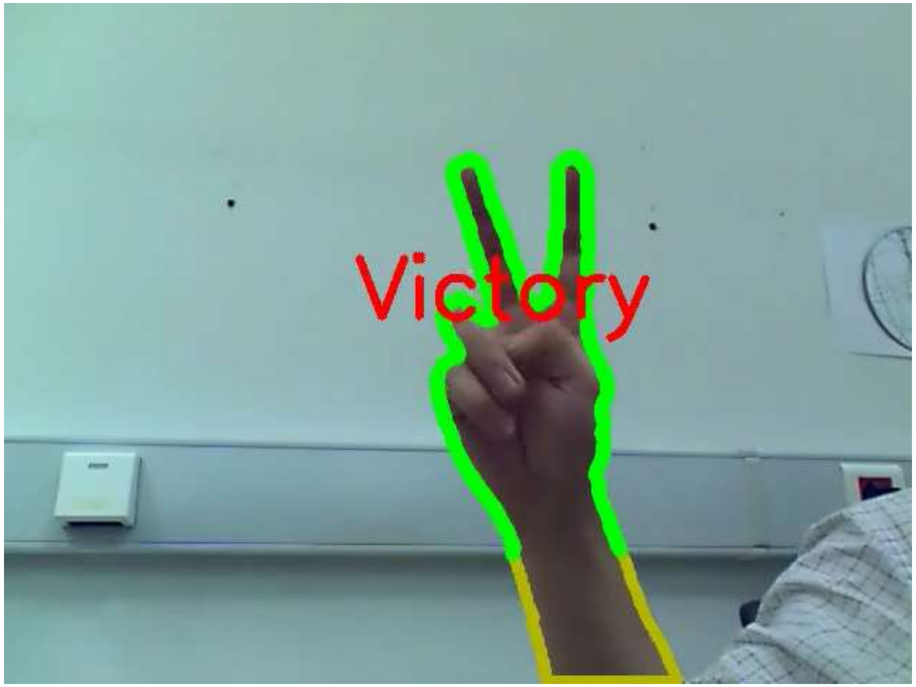
We will now see…



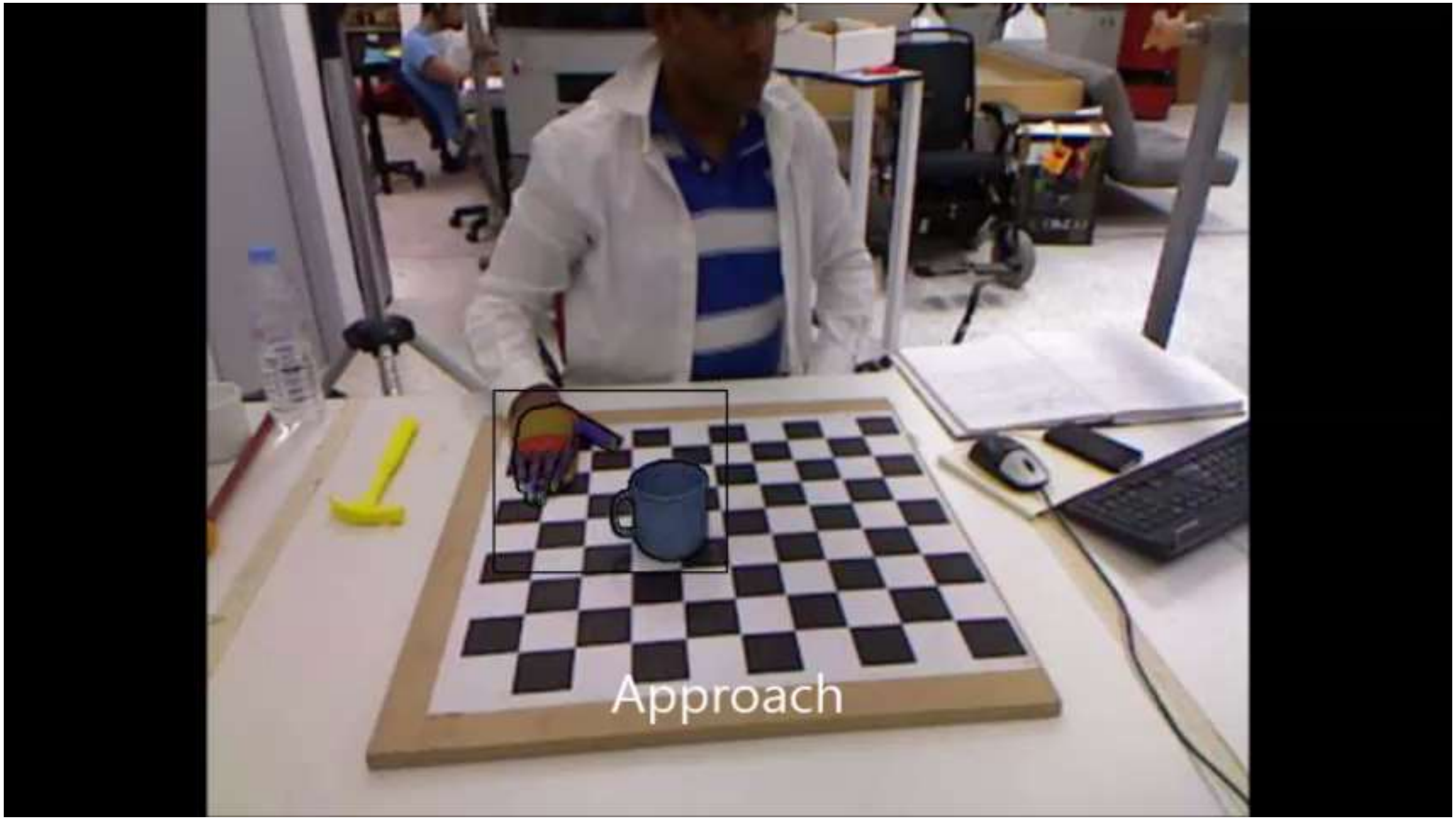
Gesture recognition



► D. Michel, I. Oikonomidis and A.A. Argyros, **"Scale invariant and deformation tolerant partial shape matching",** *Image and Vision Computing*, Elsevier, vol. 29, no. 7, pp. 459-469, 2011. [DOI] [PDF] [URL] [VIDEO]

► D. Michel, K.E. Papoutsakis and A.A. Argyros, **"Gesture Recognition Supporting the Interaction of Humans with Socially Assistive Robots"**, In *Advances in Visual Computing (ISVC 2014)*, Springer, pp. 793-804, Las Vegas, Nevada, USA, December 2014. [DOI] [PDF] [URL] [VIDEO]

Action recognition

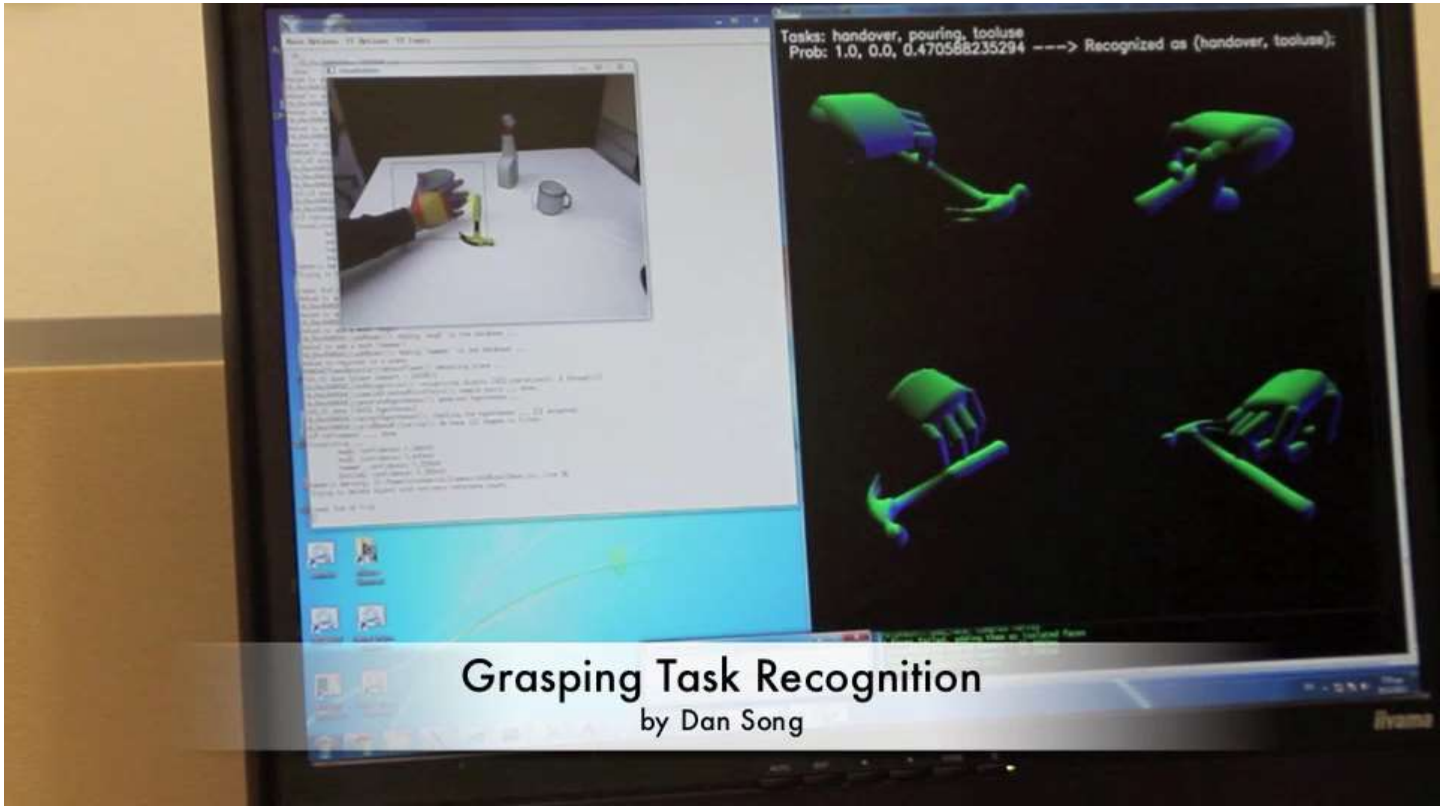


Recognize **action primitives** and **actions**

► M. Patel, C.H. Ek, N. Kyriazis, A.A. Argyros, J.V. Miró and D. Kragic, **"Language for learning complex human-object interactions"**, In *IEEE International Conference on Robotics and Automation (ICRA 2013)*, IEEE, pp. 4997-5002, Karlsruhe, Germany, May 2013. [DOI] [PDF]

Predicting human intentions

- Example: grasp for tool use, grasp for transfer



► D. Song, N. Kyriazis, I. Oikonomidis, C. Papazov, A.A. Argyros, D. Burschka and D. Kragic, **"Predicting human intention in visual observations of hand/object interactions"**, In *IEEE International Conference on Robotics and Automation (ICRA 2013)*, IEEE, pp. 1608-1615, Karlsruhe, Germany, May 2013. [DOI] [PDF].

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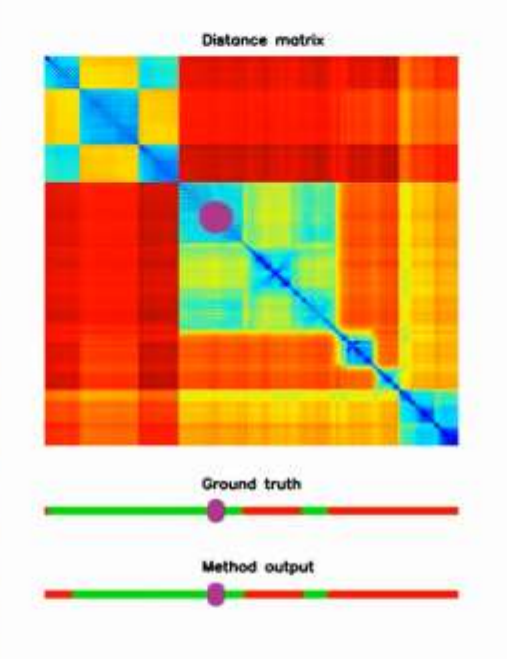
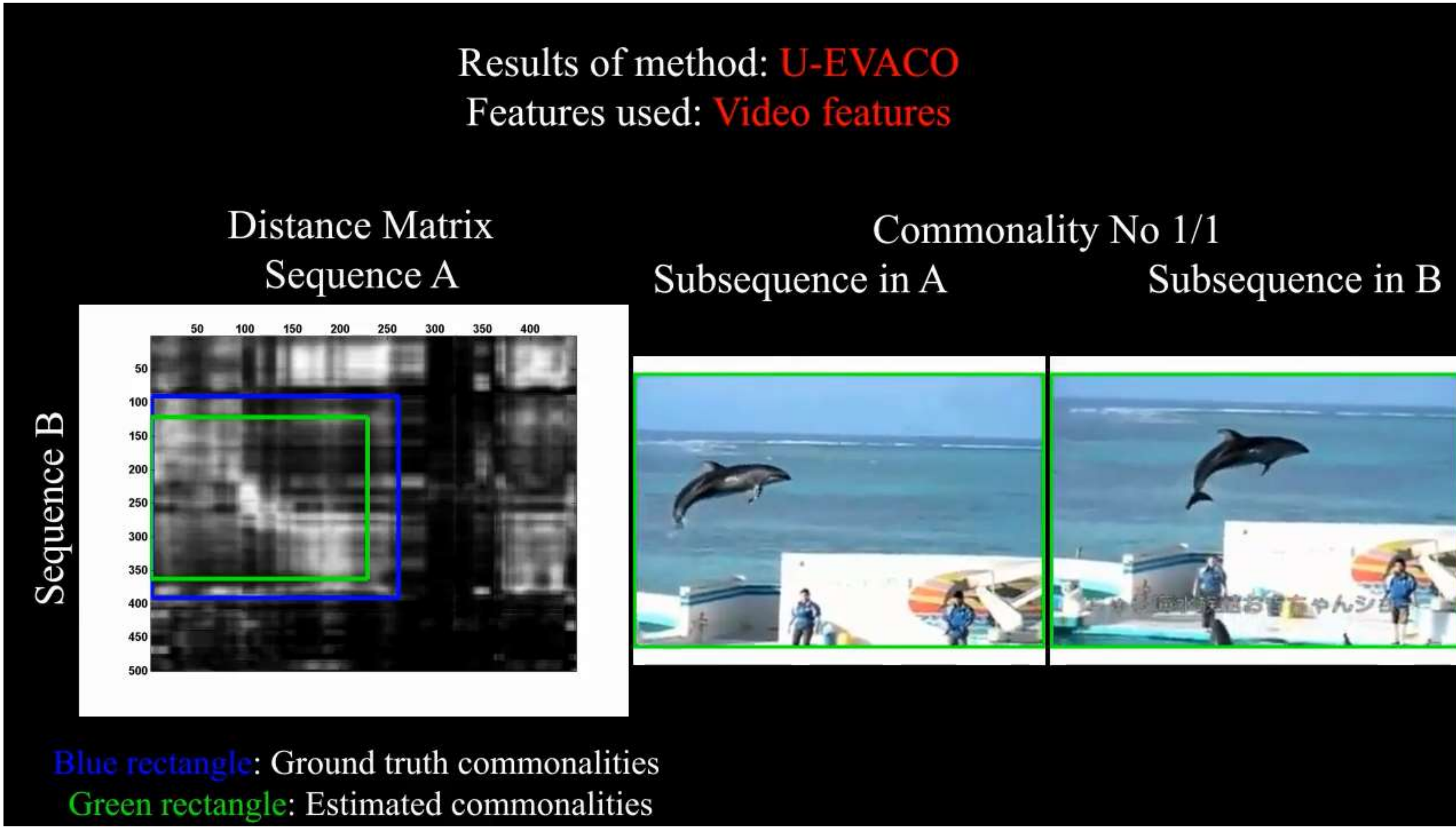
Learning to localize multiple periodic activities in real-world videos



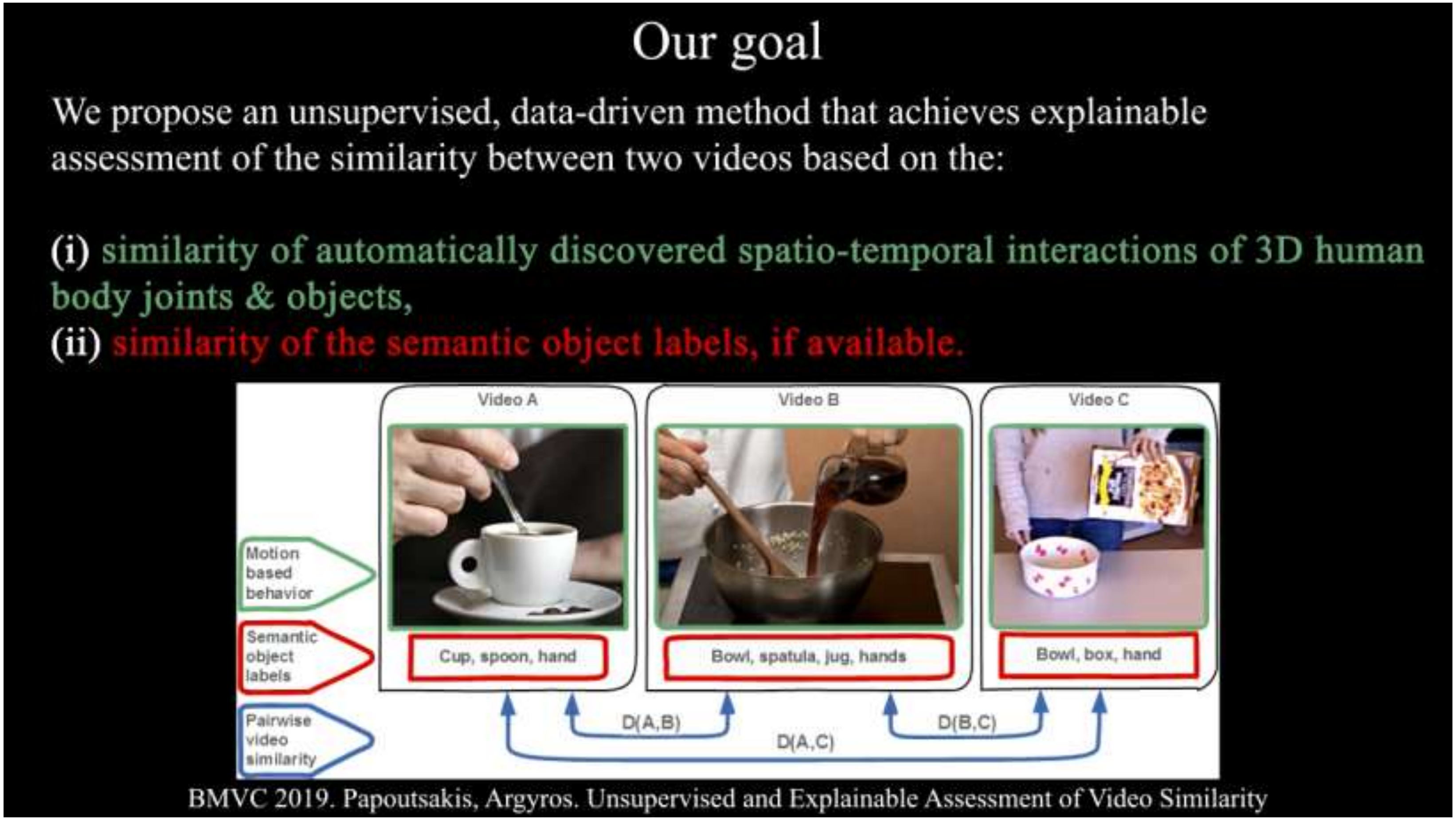
► G. Karvounas, I. Oikonomidis and A.A. Argyros, **"ReActNet: Temporal Localization of Repetitive Activities in Real-World Videos"**, In *IEEE International Conference on Computer Vision Workshops (ISV 2019 - ICCVW 2019)*, IEEE, Seoul, S. Korea, October 2019. [PDF]

Temporal action co-segmentation in 3D motion capture data and videos



► K. Papoutsakis, C. Panagiotakis and A.A. Argyros, **"Temporal Action Co-Segmentation in 3D Motion Capture Data and Videos"**, In *IEEE Computer Vision and Pattern Recognition (CVPR 2017)*, IEEE, pp. 2146-2155, Honolulu, Hawaii, USA, July 2017. [DOI] [PDF] [URL] [VIDEO]

Unsupervised and Explainable Assessment of Video Similarity



► K. Papoutsakis and A.A. Argyros, **"Unsupervised and Explainable Assessment of Video Similarity"**, In *British Machine Vision Conference (BMVC 2019)*, BMVA, Cardiff, UK, September 2019. [PDF] [URL] [VIDEO]

Applications…

Scenarios in robotics

Humanoid robot learning by demonstration

Human/robot interaction

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Robot assistants...

HOBBIT robot assistant @ home

►D. Fischinger, P. Einramhof, K. Papoutsakis, W. Wohlkinger, P. Mayer, P. Panek, S. Hofmann, T. Koertner, A. Weiss, A.A. Argyros and others, **"Hobbit, a care robot supporting independent living at home: First prototype and lessons learned"**, *Robotics and Autonomous Systems*, Elsevier, vol. 75, no. A, pp. 60-78, January 2016. [DOI] [PDF] [URL]

Hobbit

DAli, ACANTO: smart walkers

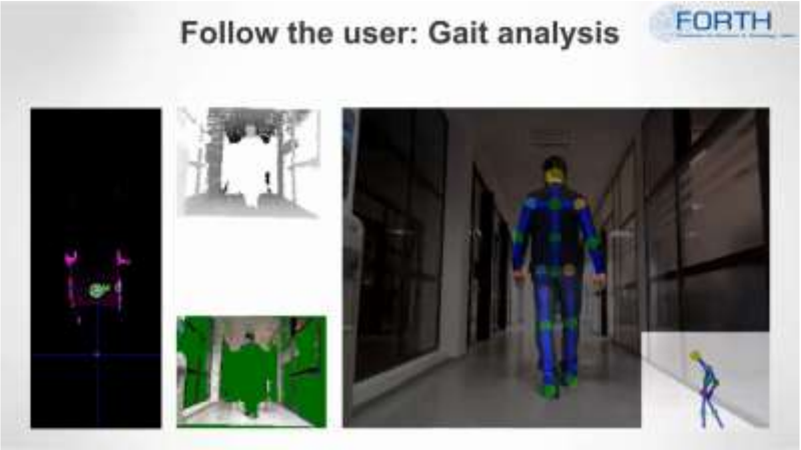
►L. Palopoli, A.A. Argyros, J. Birchbauer, A. Colombo, D. Fontanelli, A. Legay, A. Garulli, A. Giannitrapani, D. Macii, F. Moro and others, **"Navigation assistance and guidance of older adults across complex public spaces: the DALi approach"**, *Intelligent Service Robotics*, Springer, vol. 8, no. 2, pp. 77-92, April 2015. [DOI] [PDF] [URL]

Devices for Assisted Living

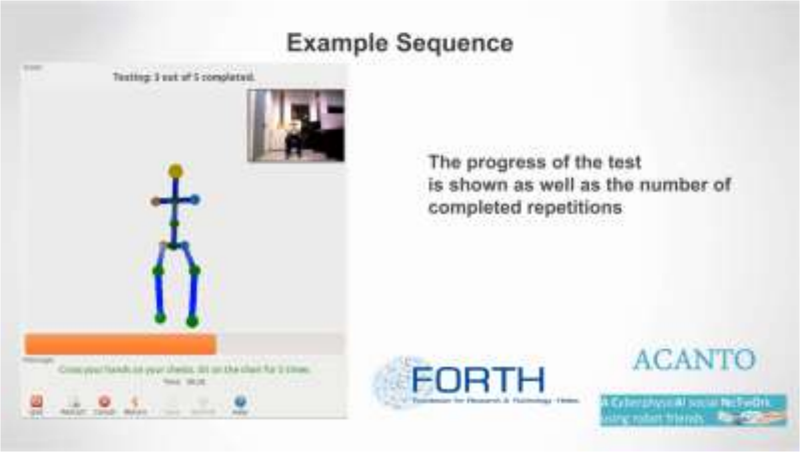
ACANTO

Healthcare

- **Gait analysis**



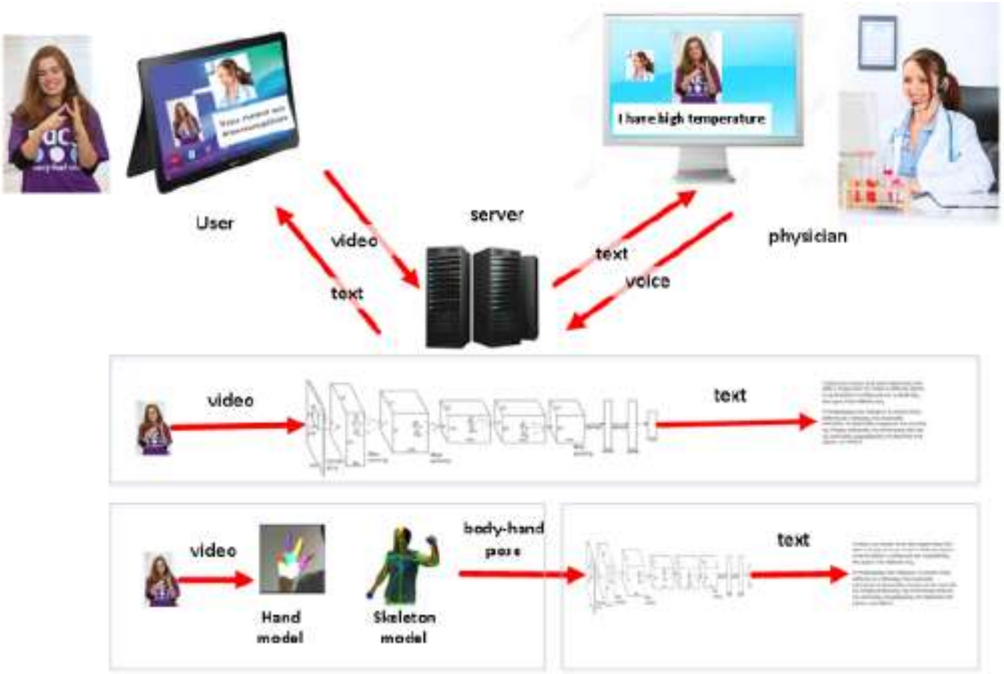
- **Sit & stand test**



► P. Panteleris and A.A. Argyros, **"Monitoring and Interpreting Human Motion to Support Clinical Applications of a Smart Walker"**, In *Workshop on Human Motion Analysis for Healthcare Applications (HMAHA 2016)*, IET, London, UK, May 2016. [PDF] [URL] [VIDEO]

The HealthSign project

- Implement an internet-based platform for synchronous communication and SL interpretation with health professionals.
- Develop in parallel a lightweight version which will be able to run on an embedded platform.
- Develop algorithms for recognition of SLs, using computer vision and deep learning using the hand and body/facial cues.
- Implement the algorithms on embedded platforms using FPGAs.
- Develop a database of GSL from native speakers with emphasis on health services.



https://tinyurl.com/HealthSignProject

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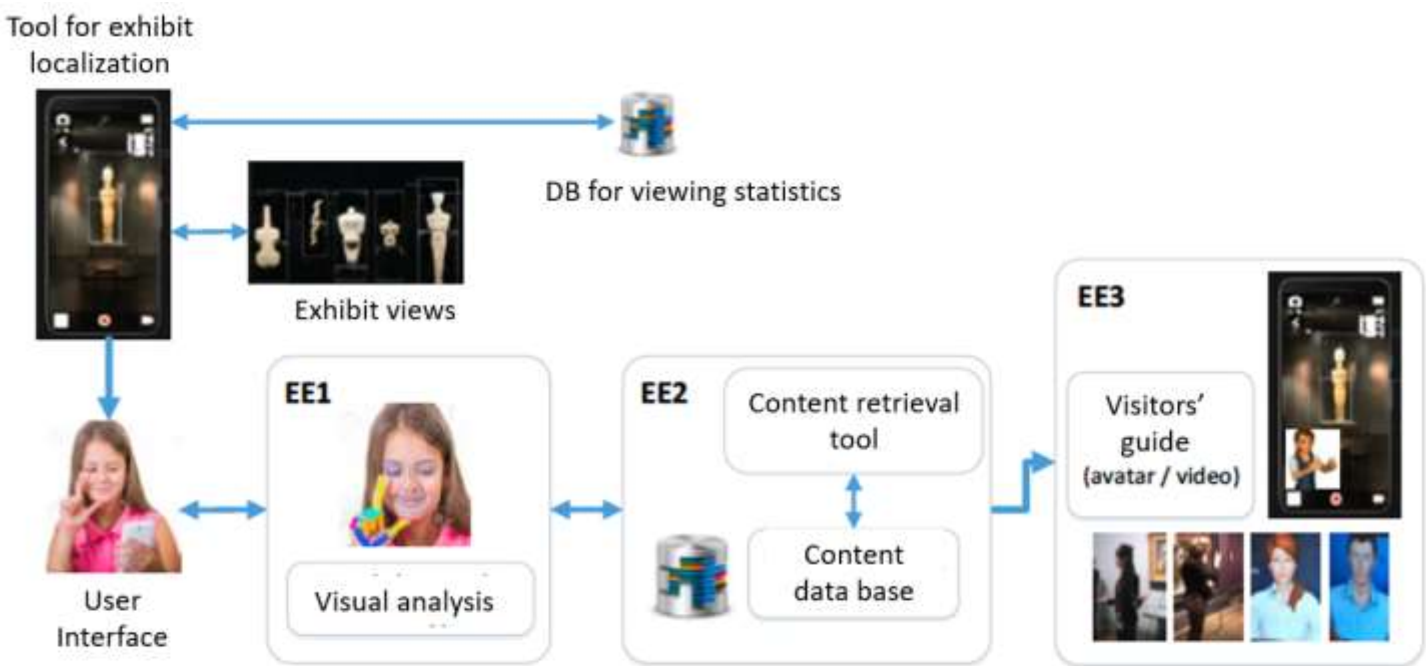
The SignGuide project

- Develop a prototype interactive museum guide system for deaf visitors using mobile devices
- Be able to receive visitors' questions in their native (sign language) with regard to the exhibits
- Provide additional content also in sign language using an avatar or video



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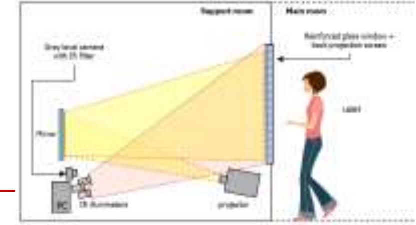
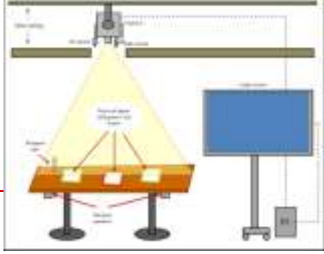
Interactive exhibits: polyapton



► D. Michel, A.A. Argyros, D. Grammenos, X. Zabulis and T. Sarmis, **"Building a Multi-Touch Display Based on Computer Vision Techniques"**, In *Machine Vision Applications (MVA 2009)*, pp. 74-77, Hiyoshi Campus, Keio University, Japan, May 2009. [PDF] [URL] [VIDEO]

Interactive exhibits: macrographia



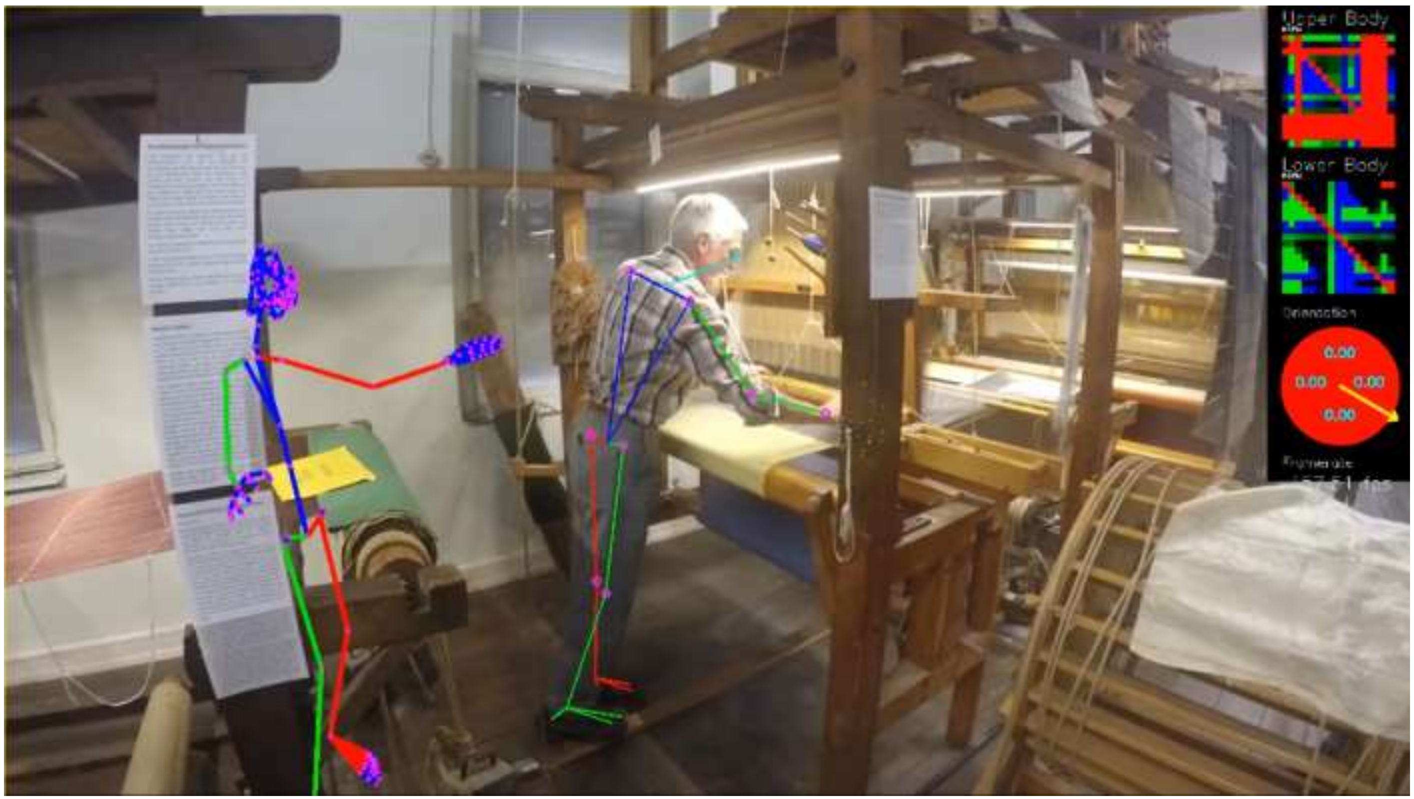
► D. Grammenos, D. Michel, X. Zabulis and A.A. Argyros, **"PaperView: augmenting physical surfaces with location-aware digital information"**, In *ACM Tangible, Embedded, and Embodied Interaction (TEI 2011)*, ACM, pp. 57-60, Funchal, Portugal, January 2011. [DOI] [PDF] [URL] [VIDEO]

Interactive exhibits: Rotating disk

X. Zabulis, P. Koutlemanis, D. Grammenos, "Augmented multitouch interaction upon a 2-DOF rotating disk", International Symposium on Visual Computing, Rethymno, Greece, 2012.

Mingei project

- ❑ Representation and preservation of heritage crafts
- ❑ Capturing the subtle details of crafts



- ❑ Project PI: Dr. Xenophon Zabulis, HCI Lab, FORTH

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Other potential applications…

- **Health** (e.g., prosthetics, patient rehabilitation)
- **Aging** (e.g., assistive technologies for elderly people)
- **Safety** (e.g., human activity monitoring in work environments)
- **Security** (e.g., surveillance)
- **Education/training** (e.g., monitoring engagement, motion analysis for sports)
- **Retail** (e.g., virtual/augmented reality)
- **Leisure** (e.g., gaming)
- **Comfort** (e.g., ergonomics)
- **Entertainment** (e.g., movie visual effects)
- **… limited only by human imagination!**

Acknowledgments: EU + national research projects

- EU project **MINGEI**
- EU project **Co4Robots**
- EU project **ROBOHOW.COG**
  EU project **WEARHAP**
- EU project **ACANTO**
- EU project **RAMCIP**
- EU project **RAPID**
- EU project **LeanBigData**
- EU project **ActiPret**
- EU project **GRASP**
- EU project **DALi**
- EU project **HOBBIT**

- HFRI project **SignGuide**
- HFRI project **HealthSign**
- HFRI project **MuseLearn**
- GSRT project **ERASITECHNIS**

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Acknowledgments: The group


A. Argyros


N. Kyriazis


A. Makris


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P. Panteleris


T. Roussos


A. Tsoli


K. Bacharidis


D. Bautembach


G. Karvounas


V. Manousaki


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