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Robots Need Language: A computational model for the integration of vision, language and action

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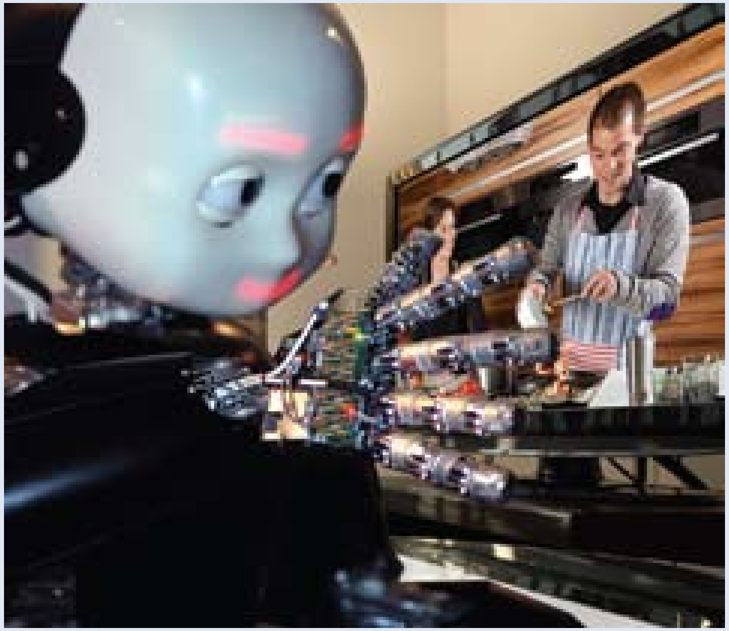
Our Proposal

- Create **Cognitive Robots** of the future:
  - *Interacts* with humans,
  - *Understands* common (complex) situations,
  - *Proposes* reasonable actions.



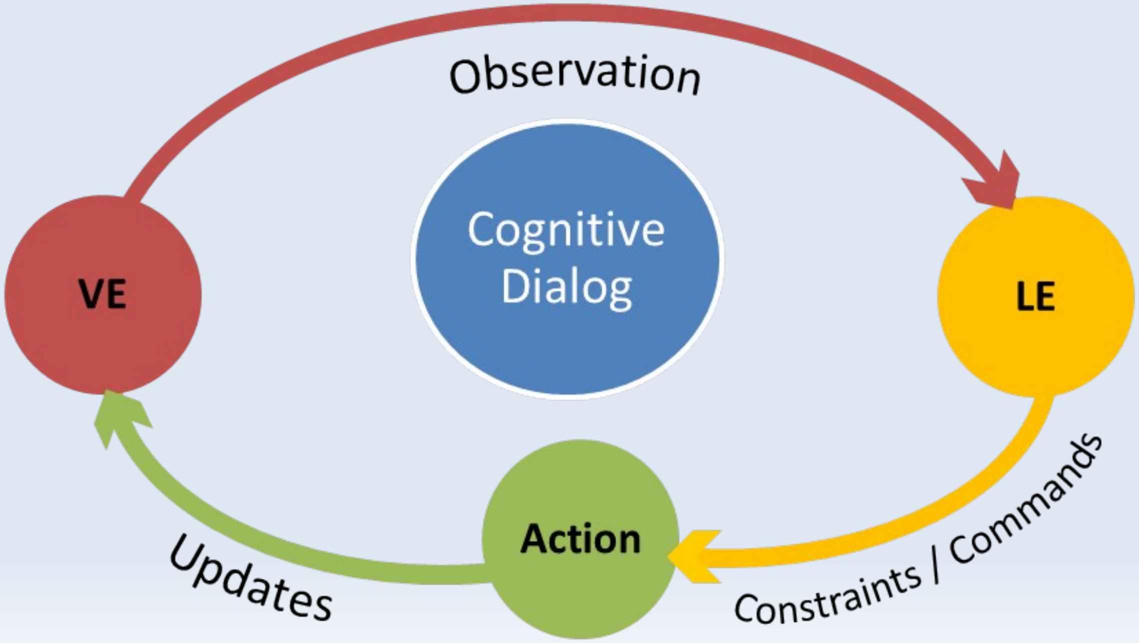
By exploiting **Language** as
a source of world knowledge

A Typical Situation

- Key questions for the robot include (but not limited to):
  - What is going on? → **Scene Understanding**
  - Who is doing what? → **Action Recognition**
  - What tools are used? → **Object Recognition**
  - ...

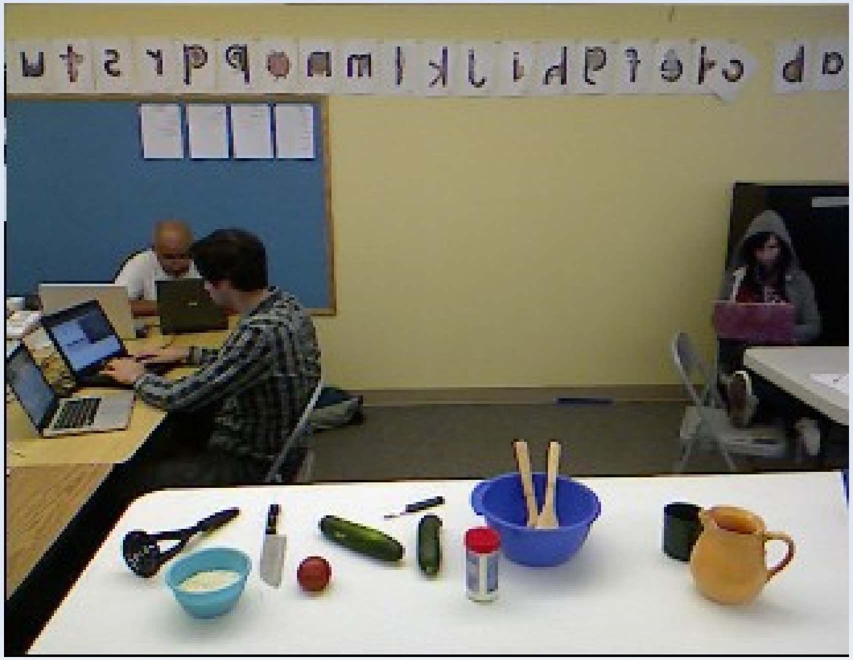
The Cognitive Dialog Framework

- A model of a reasoning process that involves the **Visual Executive** (VE) and **Language Executive** (LE), with **Action** in the middle:
- *VE*: observations to *LE*, e.g. low-level feature extraction,
- *LE*: constraints from knowledge, proposing reasonable responses,
- *Action:* Performs actions, updates *VE.*



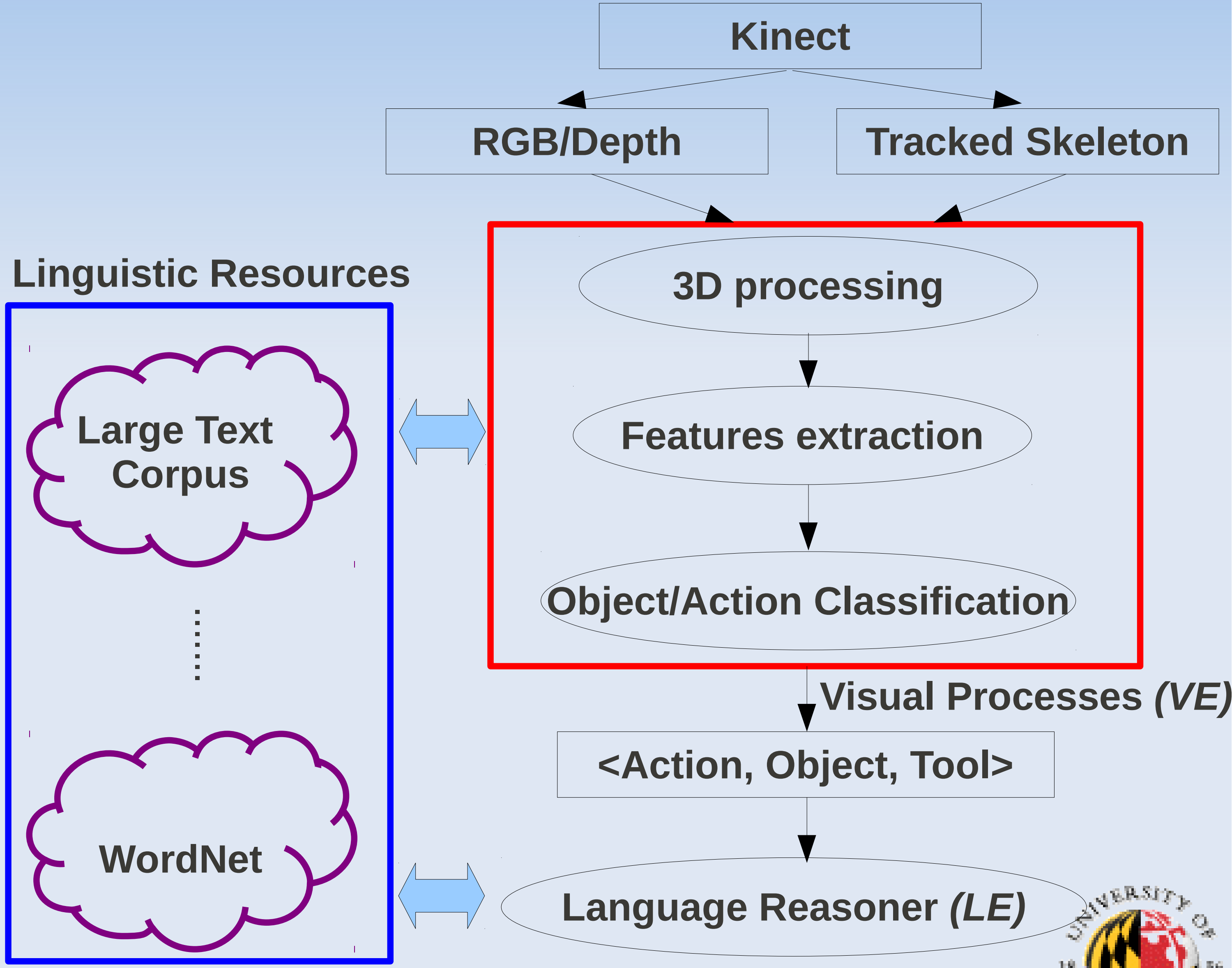
Implementation

- Limit ourselves to *Kitchen Scenarios:*
    - Highly structured, with clear instructions from a recipe: tools, ingredients, step-by-step procedure.
    - Well annotated dataset, with variations.
- Task for robot is to **describe what is going on**



*< The human is **stirring** the **bowl** using **fork/spoon**>*

Key HW & SW Components



Kinect

RGB/Depth

Tracked Skeleton

Linguistic Resources

Large Text Corpus

WordNet

3D processing

Features extraction

Object/Action Classification

Visual Processes *(VE)*

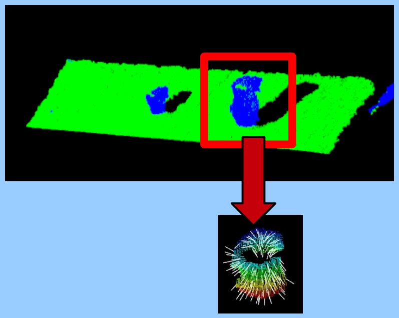
<Action, Object, Tool>

Language Reasoner *(LE)*

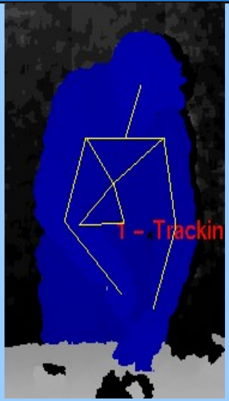
SW Highlights

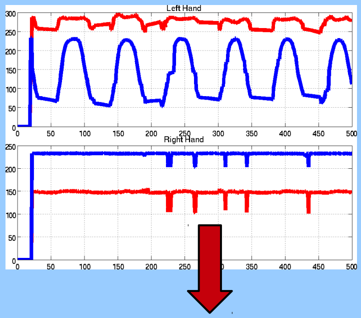
Hardware: Kinect, PTU, Laser, Pioneer

Attention-Guided Navigation



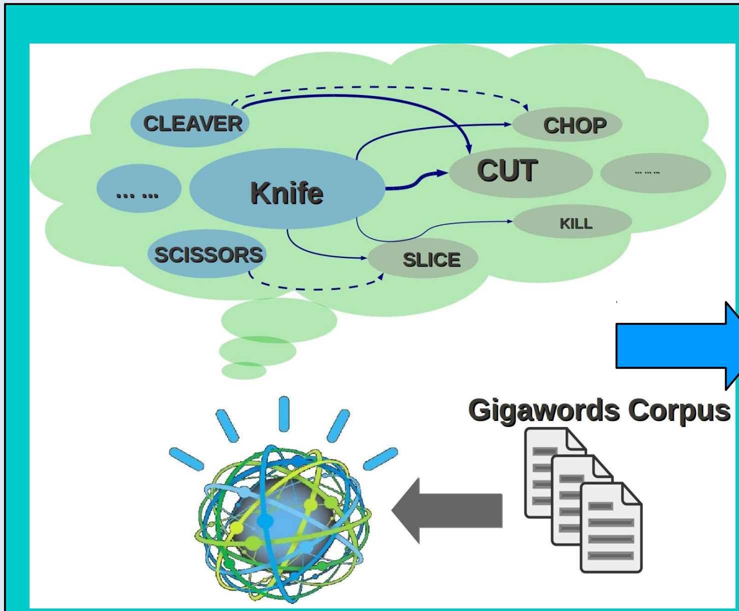
Plane + Object Detection



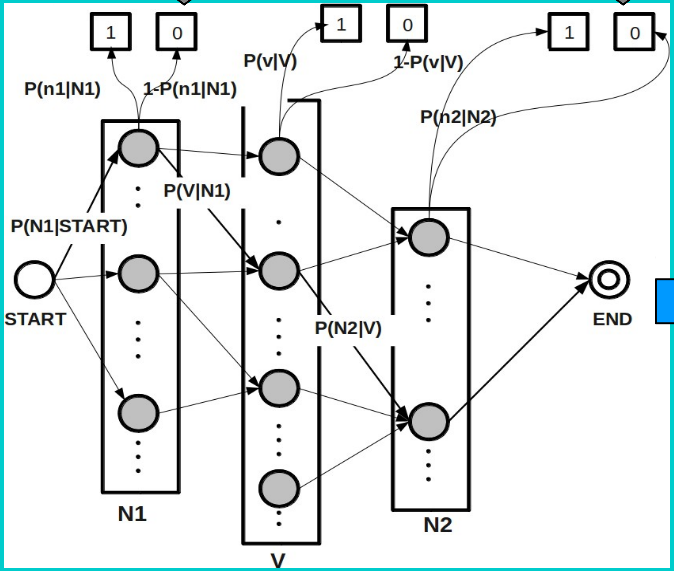


[… 0 2 1 3 4 4 4 5 5 …]

Action Attributes Encoding



Object-Tools Co-occurrences



Optimization of Visual + Language information[1]

*< The human is **cutting** the **bagel** with the **knife** >*

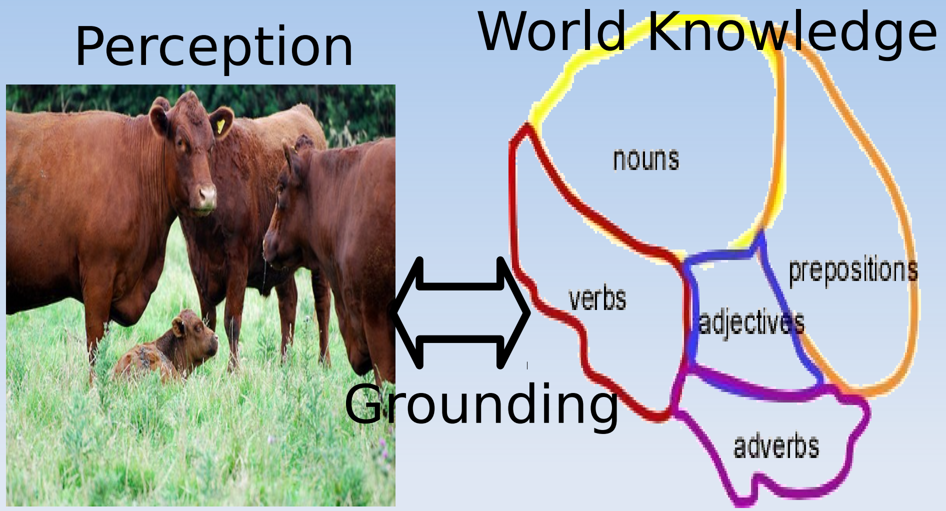
Sentence Generation

[1] Ching L. Teo, Yezhou Yang et al. Corpus-Guided Sentence Generation of Natural Images. EMNLP. 2011.

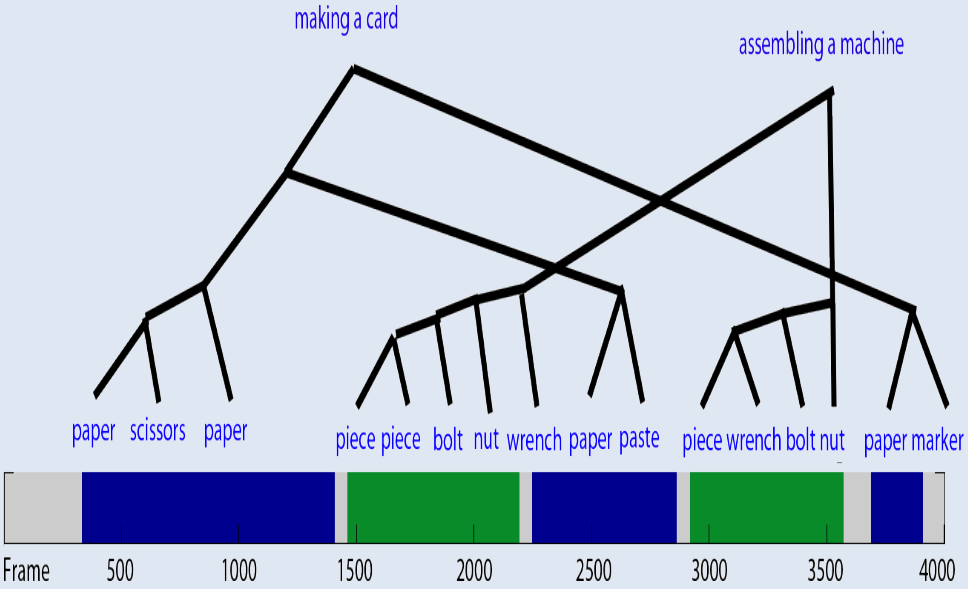
Demo Video

On-going Work (1)

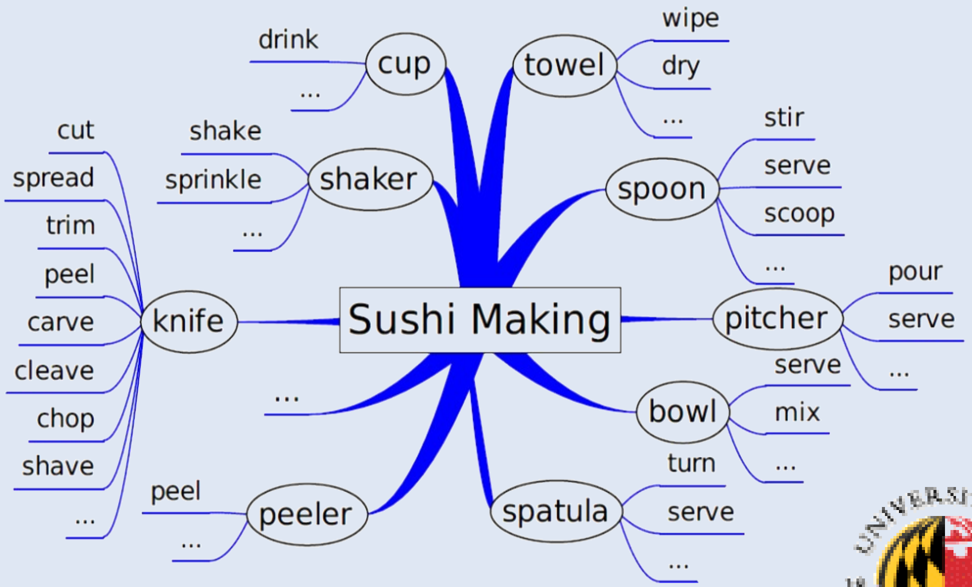
Attributes-based Recognition



Grounded Scene Understanding



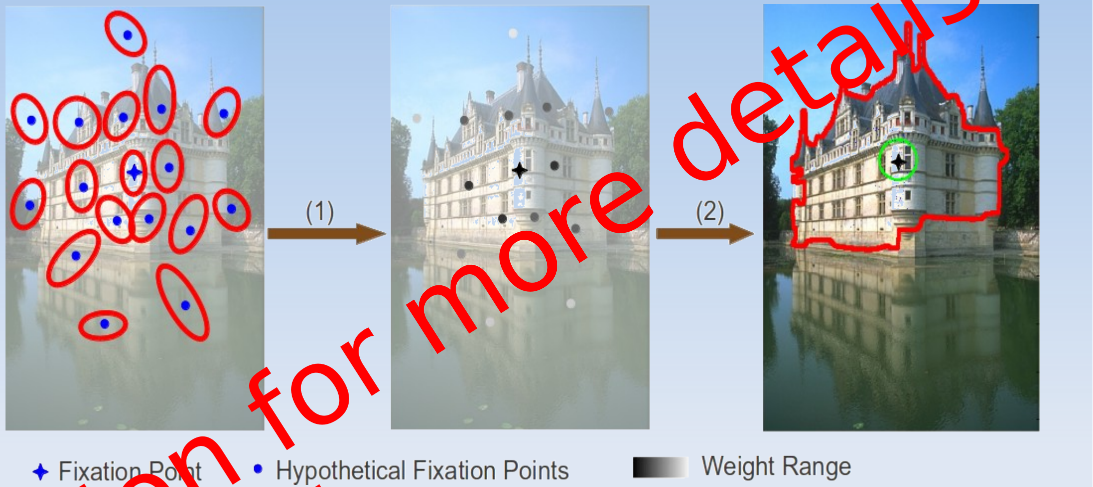
Action recognition from Activity Tree Grammar



Generating High-Level Concepts

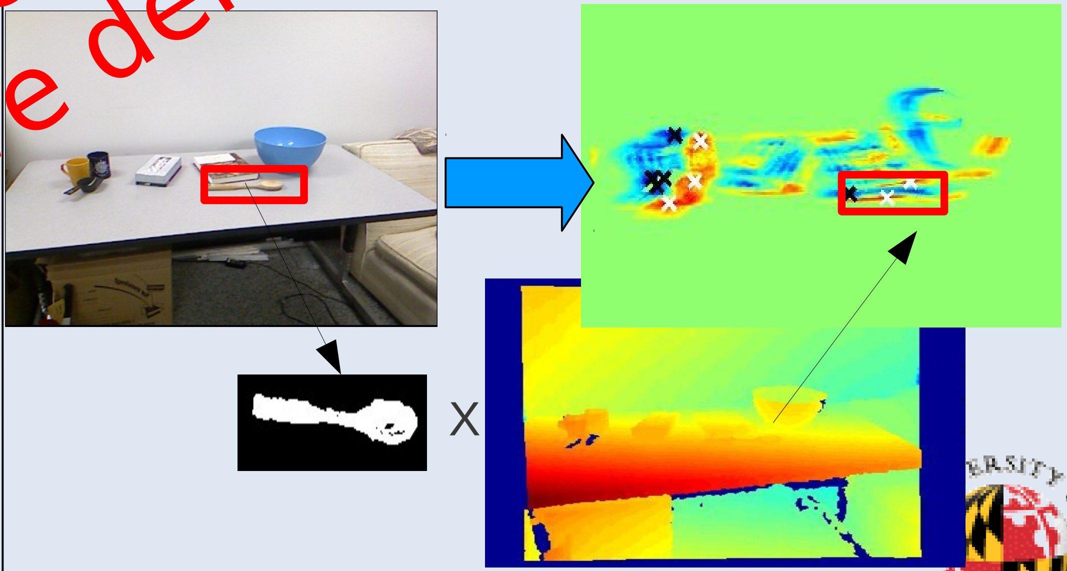
On-going Work (2)

Manipulative action understanding



Attention-based Segmentation+Tracking

Action recognition via cause-effect



Object search using high-level knowledge

Come to our poster session for more details

+ live demo!

Conclusion

- Current Computer Vision techniques are limited when low-level signals are used:
  - Introduced *language* as a **key enabler** for *perception* to occur
- Formulated the interplay of vision and language as a **Cognitive Dialog**:
  - Algorithms developed around this framework
  - Suitable for cognitive robots of the future
- Beyond integration at the *semantic* (label) level:
  - Numerous on-going work on integrating language into all levels of perception

Thank You

- We would like to thank:
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