Leveraging spatial memory for shortcuts through mid-air deictic pointing using Microsoft Kinect

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IAD Master, research internship 2012

Presentation plan

A future home...

Microsoft Research's "home of the future"

... with lots of functions

Our problem

- **Shortcut management** :
  Fast, occasional, sporadic
  $\Rightarrow$ Micro-interaction techniques
- **Couch-interaction** :
  In air, no additional device
  $\Rightarrow$ Low-cost depth camera : Kinect
- **Huge memorization capacity**
- **Easy and fast learning** : novice $\rightarrow$ expert transition
  $\Rightarrow$ Spatial cognition

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A similar problem, a different time...

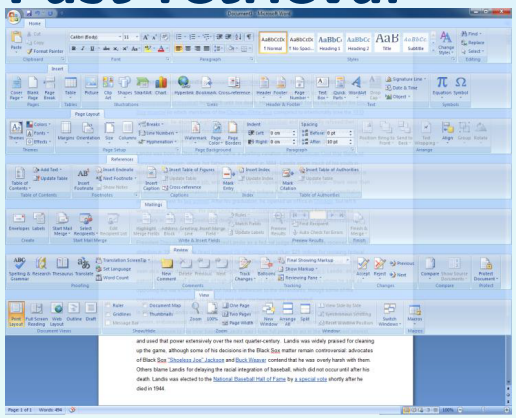
Roman villa reconstruction

The method of loci

Spatial cognition

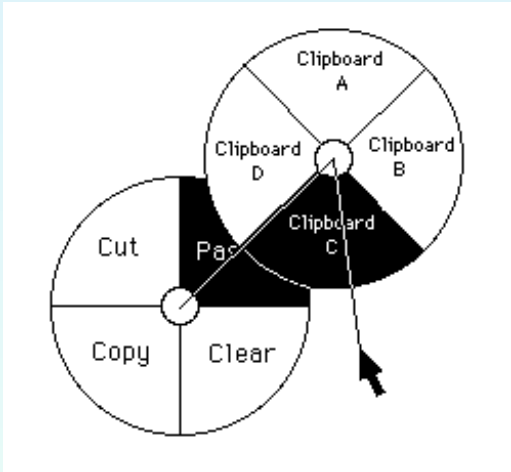
Plays a major role in performance in user-interfaces

Fast retrieval



CommandMaps

Smooth learning



Marking Menus

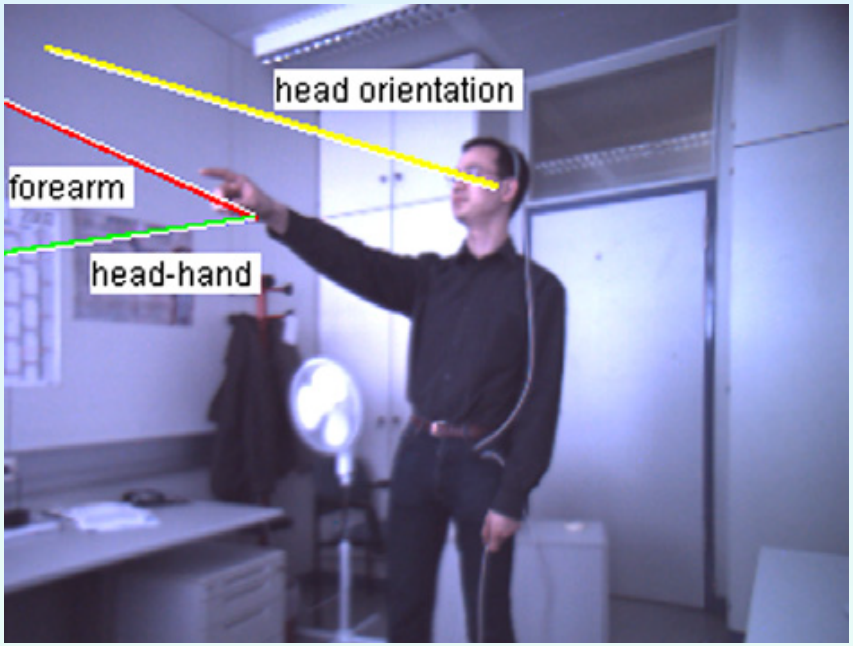
Big long-term memory

Data Mountain

Can even leverage **proprioception**

Pointing

"What you point is what you get"

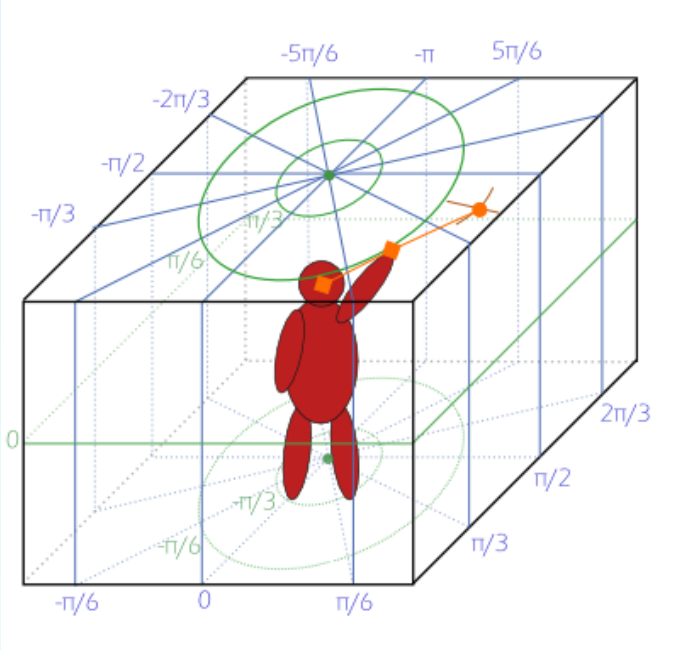


Validation by closing hand

Pointing challenge

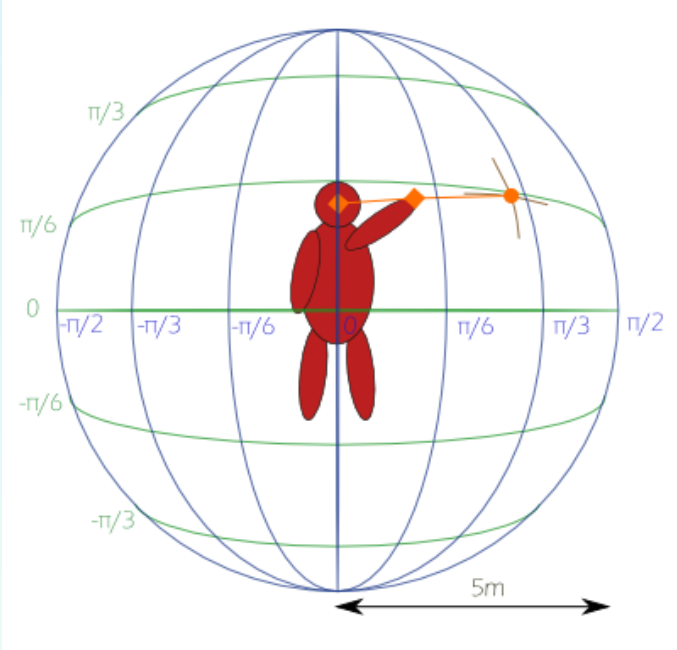
Inferring the environment from partial imprecise information

Room paradigm



Hard calibration

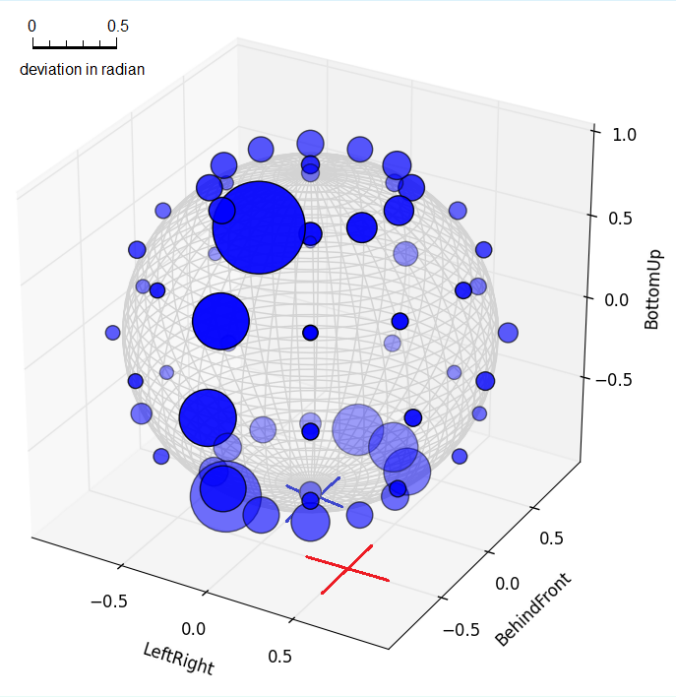
Sphere paradigm



Approximation

Measure of the precision for every polar angle

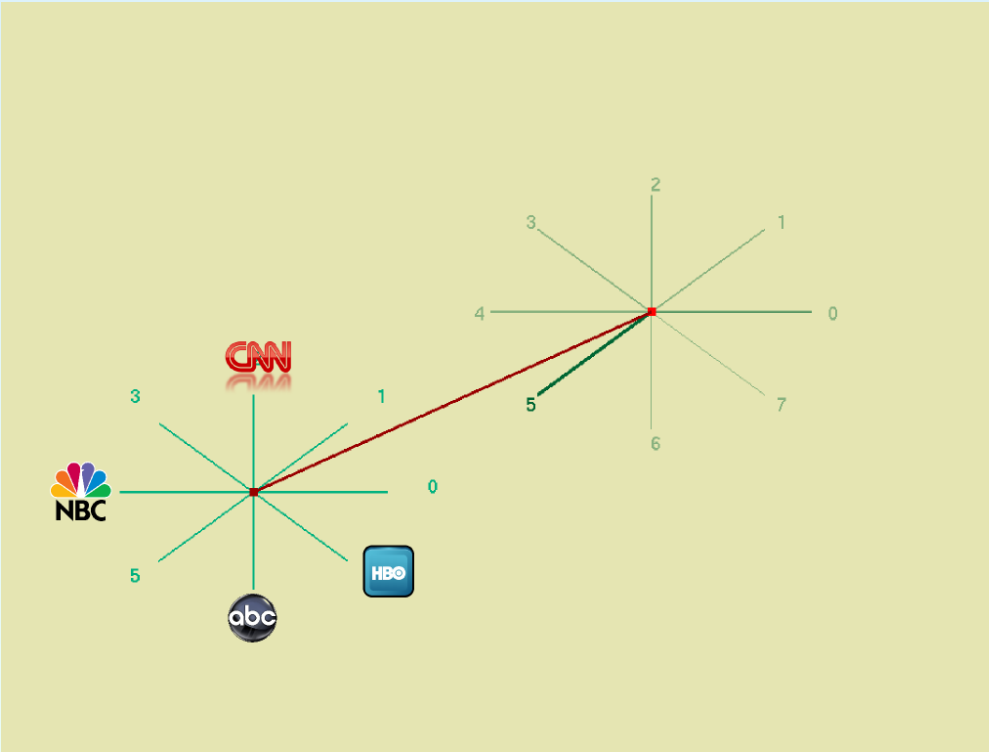
Precision of the system



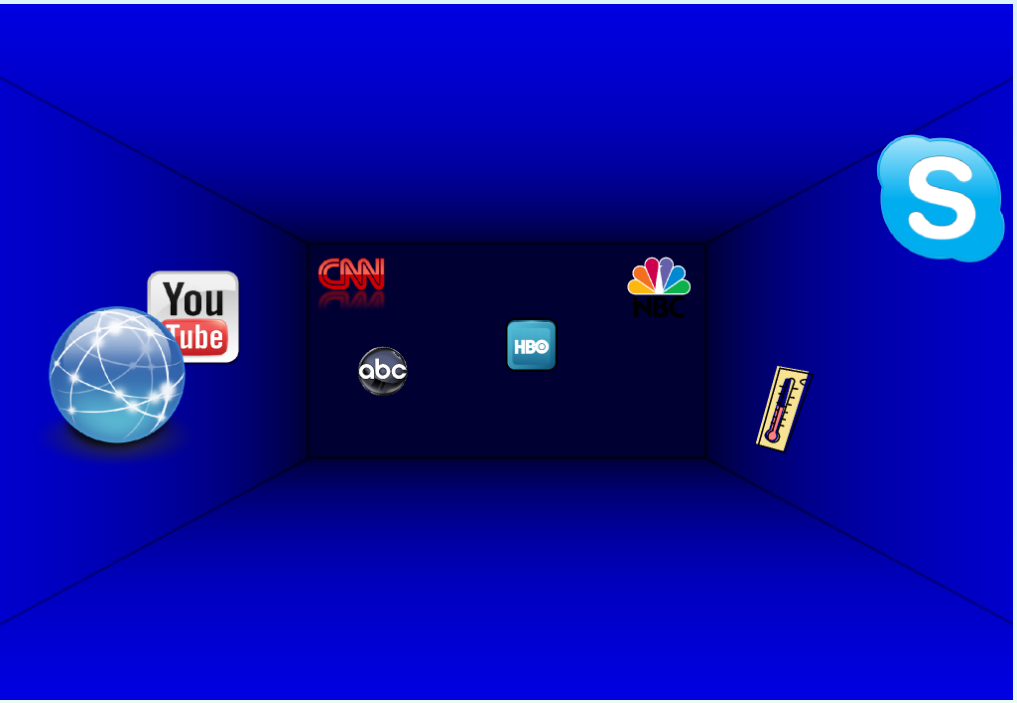
- **No big difference between paradigms**
- Small loss of precision when not centered
- No difference between θ and ϕ precision
- Big deviation to ground truth (40cm) but low standard deviation (10cm)

SMM : Spatial Marking Menus

- **In-air marking-menu** :
  2 directions (hierarchical)
  Relative movement
- Limited capacity (8x8)
- Oblivious to the environment
- Manipulating on a virtual plane
- Interactive (partial) feedback



SPS : Spatial Pointing Shortcuts



- **Novel microinteraction** :
  direct deictic pointing
  based on the environment
- "Unlimited" capacity
- Closest item selection
- Double feedback mechanism :
  - Imprecise "map"
  (approximate and relative position)
  - Precise audio on hoover

Techniques evaluation

Protocol : starts with example,
position items, 3 learning phases, 1 phase without feedback

- **Measure the use of feedback** (on-demand help)
- **Measure kinect-related errors** :
  The experimenter asks where the subject wanted to point
- Neutral vocabulary
- Click to validate
- Both hands usable
- Visual cues added to the room

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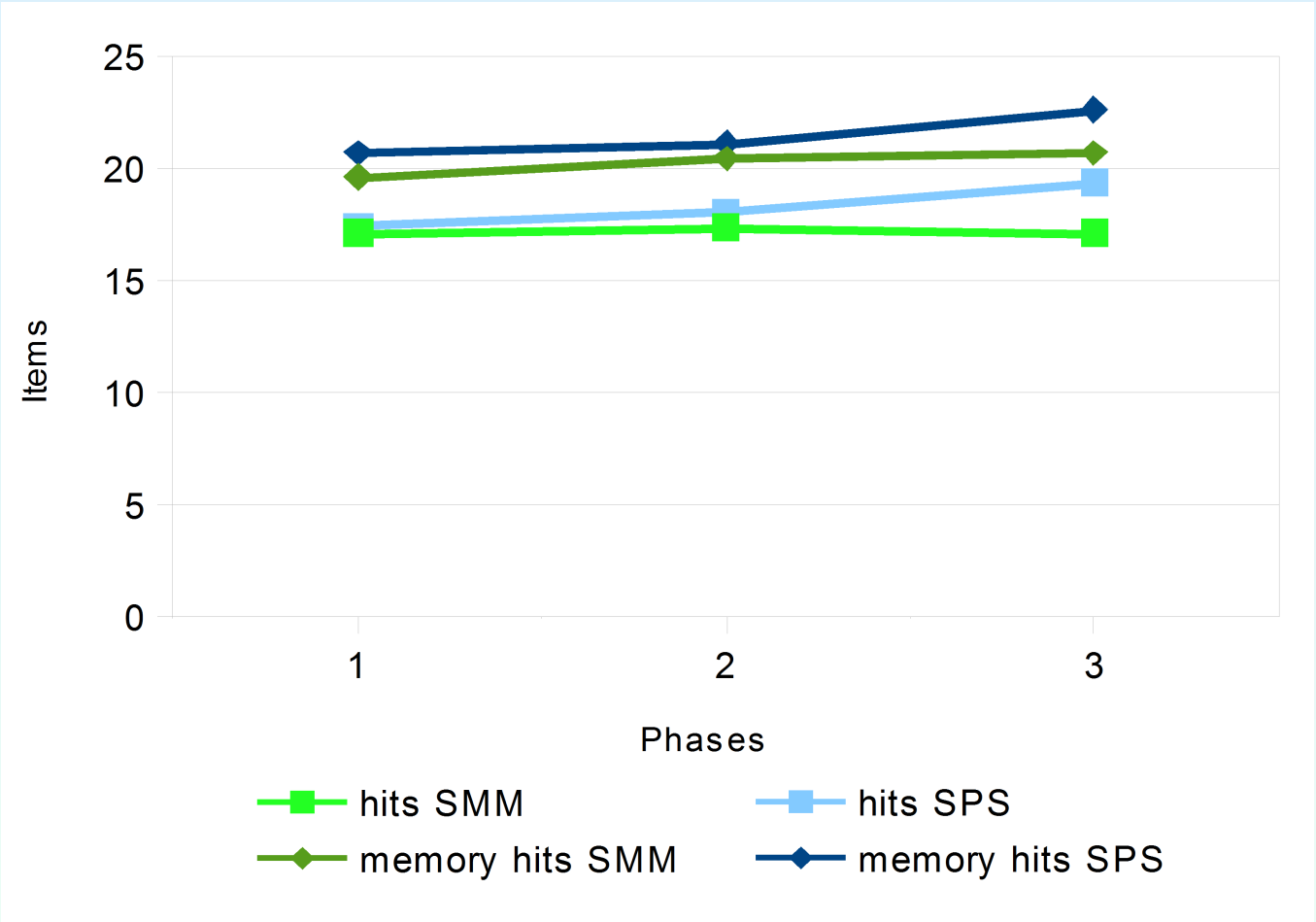
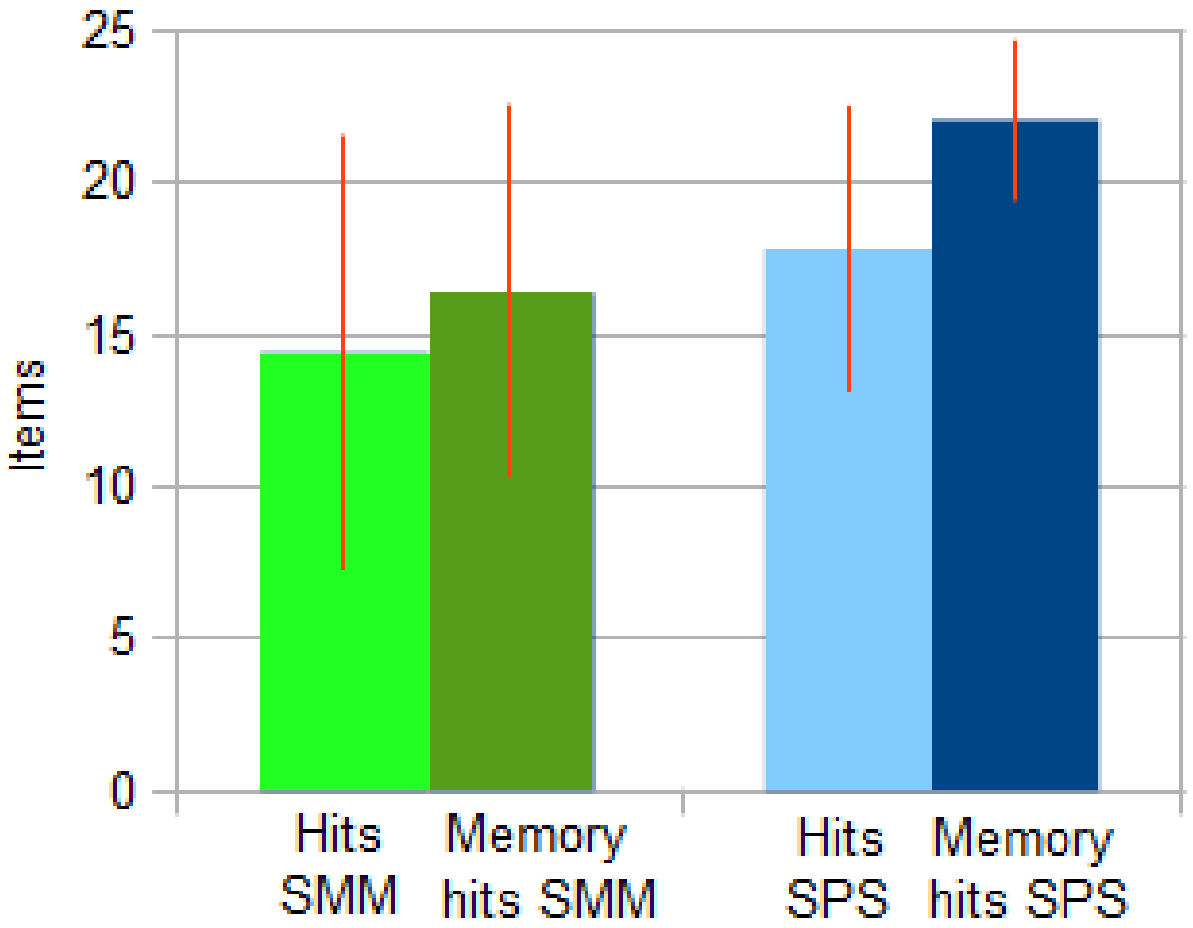
Global learning performances



No significant difference

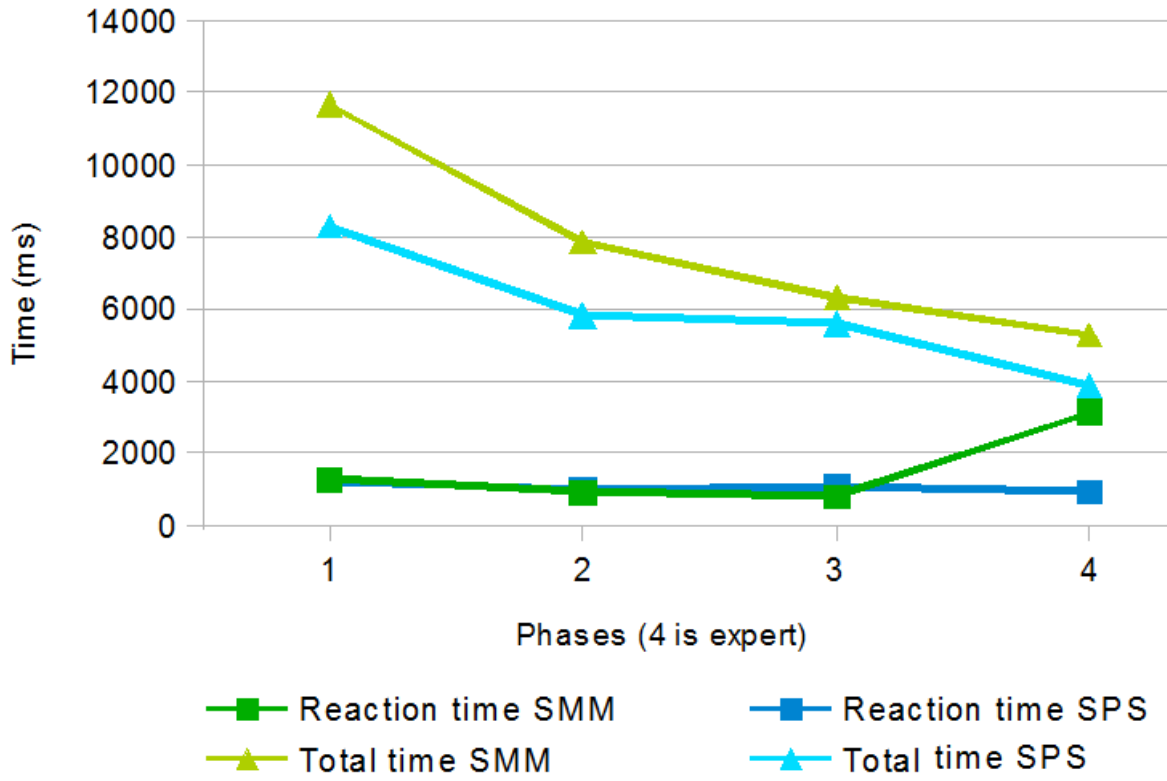
Kinect imprecision errors : 12%

Memorization performances



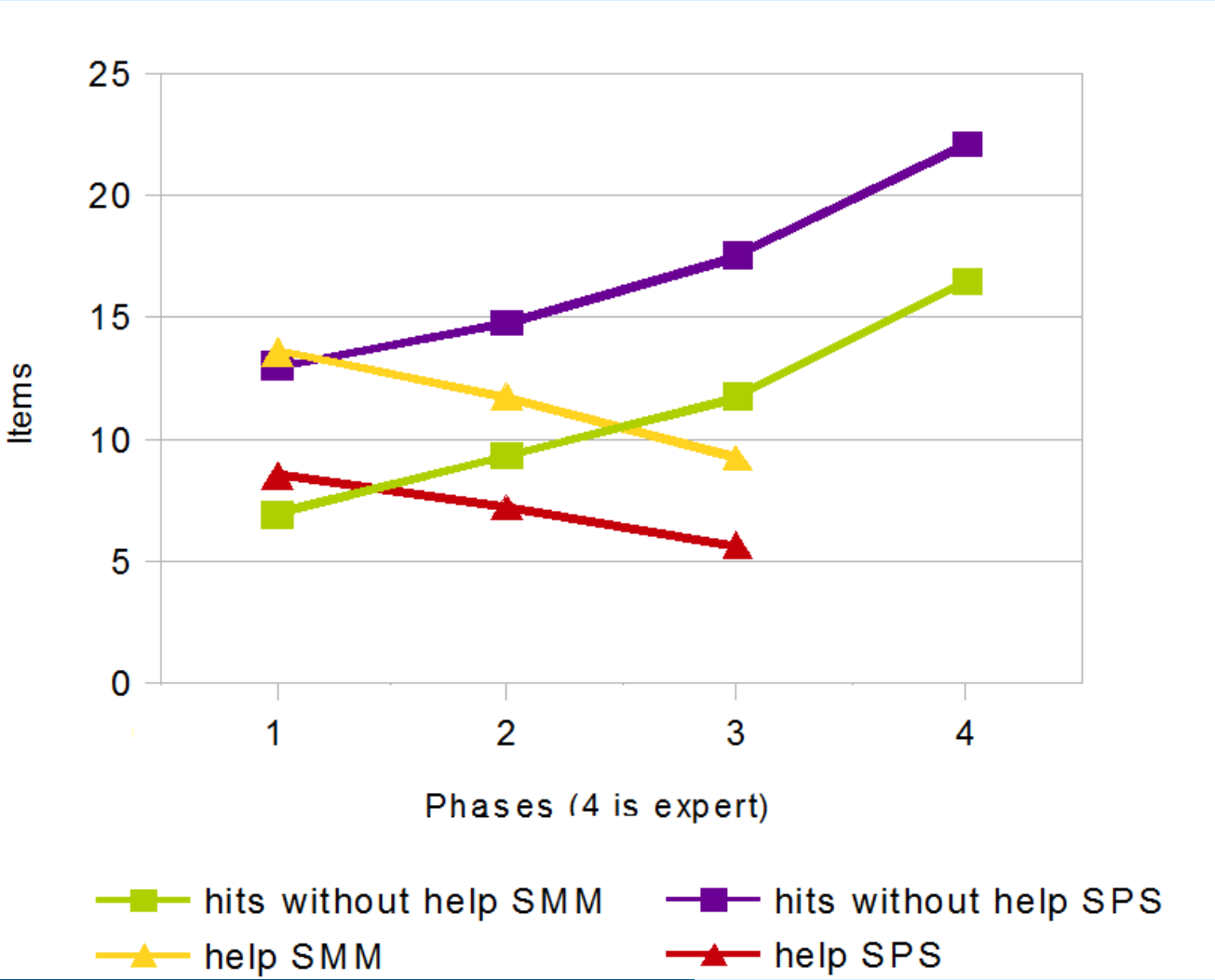
Very significant difference

Time performances



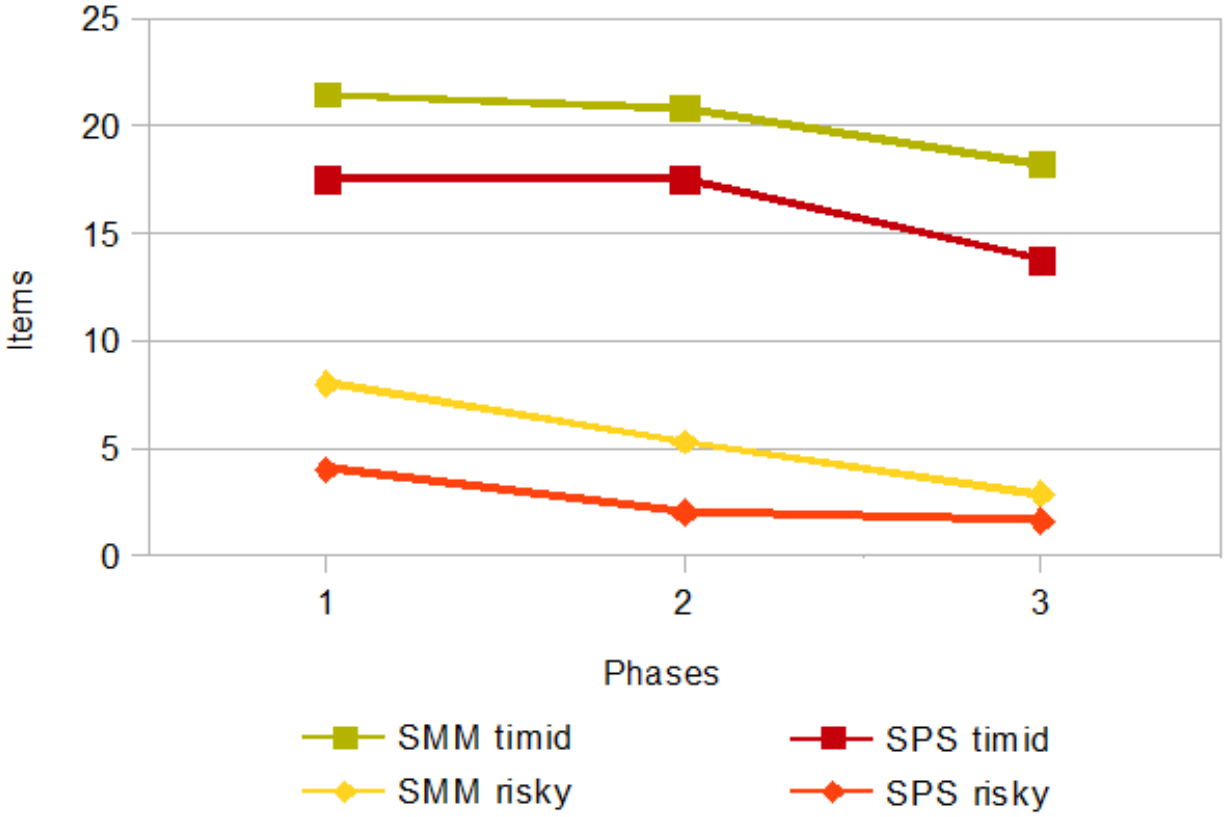
SPS significantly faster

Novice to expert transition



Difference not statistically significant

Help usage profiles



Two behaviors : significant impact on performances, **not** on learning rate

User perception

SPS is prefered, perceived as significantly :

- more fun
- easier to get to grasps with
- easier to learn with

SPS is less tiring, but SMM allows for easy organization of items

Qualitative observation

- Most user mix chaos and organization
- Organization helps memory
- Spatial and proprioceptive memory

Mnemonic devices include :
similar or opposite directions, memories, semantic mapping, visual mapping, sentiment mapping, visual memory (shape, color), audio memory, storytelling...

Contributions

- Efficient **pointing paradigm** to infer the environment from partial imprecise input
- Two **micro-interaction techniques** leveraging spatial memory to outperform the state of the art

$\Rightarrow$ Submitted as a long paper to ACM CHI 2013

Conclusions

SMM *(Spatial Marking Menus)*	**SPS** *(Spatial Pointing Shortcuts)*
Hierarchical, limited	Chaotic, direct, unlimited
Environment oblivious	Environment based
Interactive feedback	Bimodal feedback
...	Faster, preferred
16.4 learned items	22.1 learned items
Interactive feedback	Bimodal feedback
Great for organizing	Great for direct retrieval

$\Rightarrow$ Combine the strengths of the two techniques

Questions ?

Thank you for your attention.

More information and bibliography found in the report.

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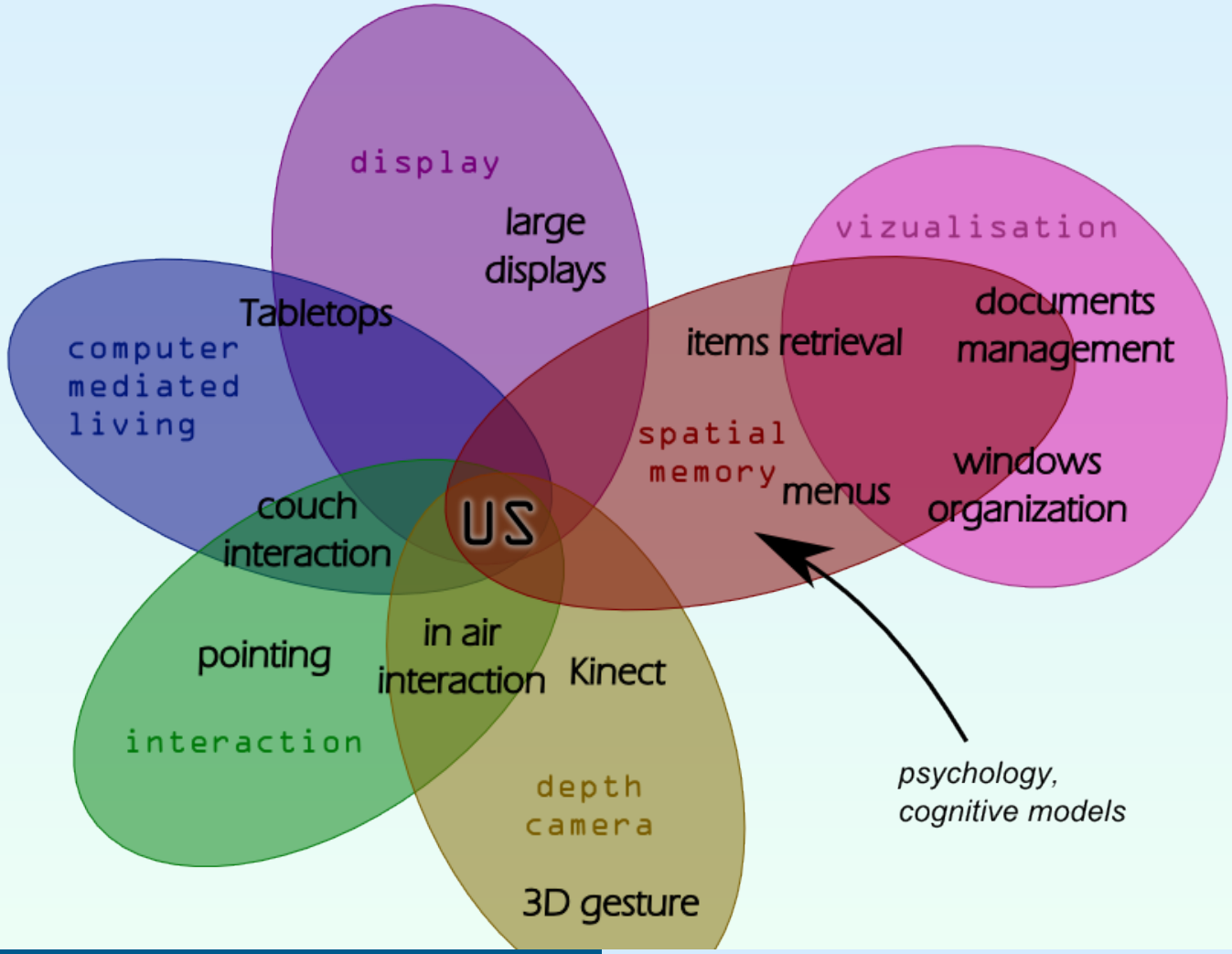
Where do we stand ?



A word about Kinect

Low-cost depth camera from Microsoft :
Light coding, ~~Time of flight~~

- RMSE (right, away, upwards) : 6.5cm, 10.9cm, 5.7cm
- Less precise when further away ($y > 3.0$m)
- Field of view : $(58.6^\circ, 43.6^\circ)$; [0.47m - 3.6m]

~~Microsoft Kinect SDK~~, **OpenNI**, ~~Libfreenect~~
C++ (openGL), ~~C#, Java~~