HABILITATION THESIS

Virtual Environments for Education, Training and Cultural Heritage

Candidate: Dorin-Mircea I.M. POPOVICI

Domain: COMPUTERS AND INFORMATION TECHNOLOGY

Affiliation: Ovidius University of Constanta
Research Laboratory in Virtual and Augmented Reality (CeRVA)

Transilvania University of Braşov

14.09.2016

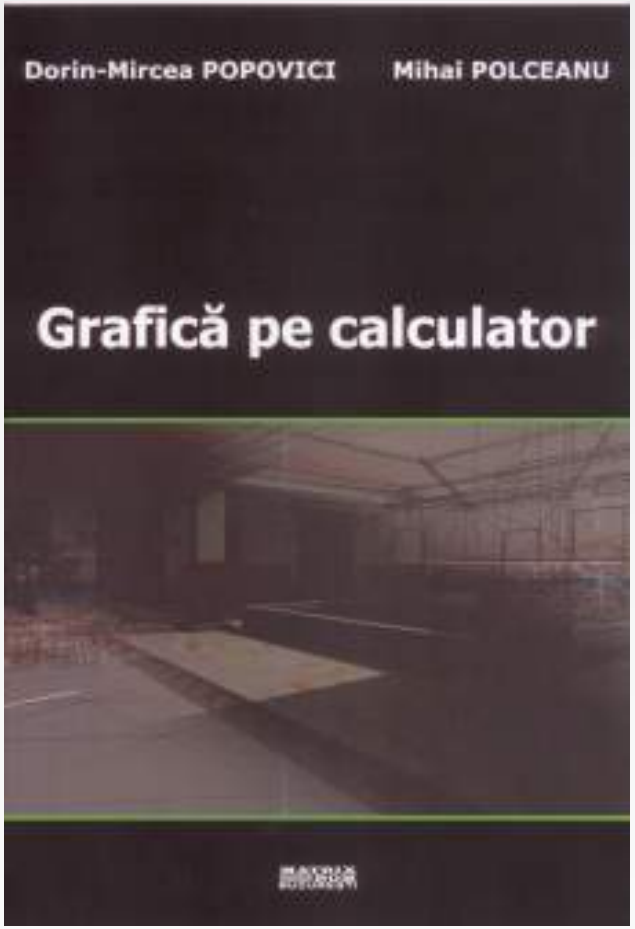
Research & Pedagogical Context

- Diplomas:
  - 2005 : PhD in Computer Science: Politehnica University of Bucharest - ”Modeling the space in virtual universes” - CUM LAUDAE
  - 1991 : Bachelor in Mathematics: University of Bucharest
- Professional experience:
  - 1991-present : assistant, teaching assistant, associate professor, professor: Ovidius University of Constanţa
    - Research Laboratory in Virtual and Augmented Reality
    - CeRVA: http://www.cerva.ro
  - 2003-2005 : researcher - ATER: ENIB, France
    - European Center of Virtual Reality
    - CERV: http://www.cerv.fr

Pedagogical activity

Courses, labs and seminars

- Informatics, Basics of Computer Science
- Advanced Programming Techniques
- Evoluated Programming Languages
- Object-oriented Programming
- Compilers Theory
- Software Engineering
- Computers' Architecture
- Computer Graphics



- Bachelor thesis : Programming Languages, Computer Graphics, Distributed Virtual Reality

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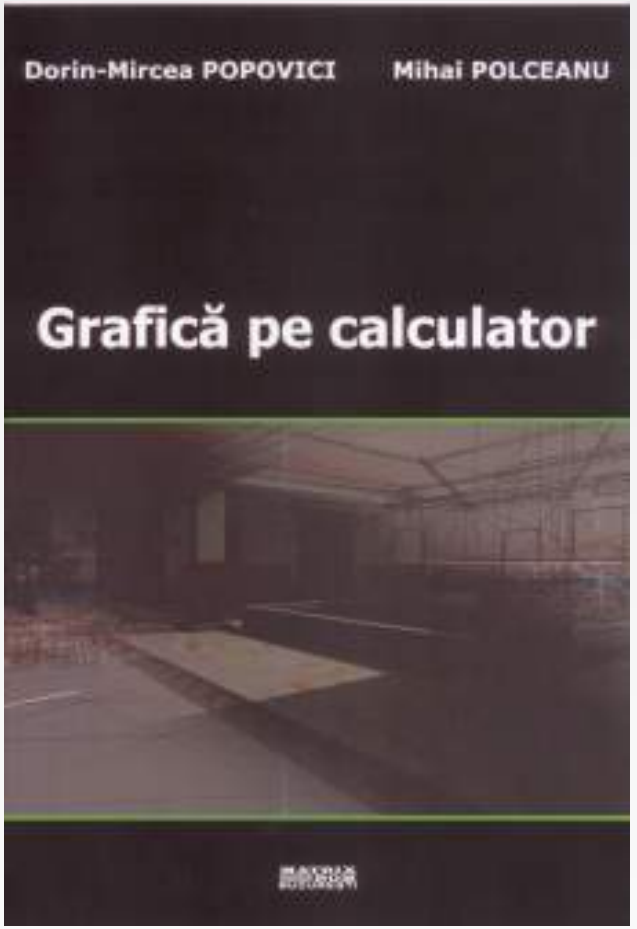

  - Bachelor thesis : Programming Languages, Computer Graphics, Distributed Virtual Reality

Courses and practical activities

1. Informatic Models and Technologies
   - Multiagents Systems,
   - Virtual Reality.
2. Distributed Multimodal Virtual Environments
   - Virtual and Augmented Reality,
   - Multimodal Interfaces,
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3. Using Virtual Reality in Sports
4. Master thesis : Semantical Modeling of VE, Behavioral Ressources Reuse, Natural Interaction within VE.

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Contests and Summer schools

- ACM Programming Contests for South-East Europe, Politehnica University of Bucharest, 1999-2001.
- "Leadership, antrepreneurial development and virtual environments - Virtual Environment Section", Economic Studies Academy, Bucharest, 2002 - 1^{st} prize.
- "1er FORUM DES TECHNOLOGIES DE L'INFORMATION - Virtu@Brest", Brest, France, 2002 - 2^{nd} prize.
- AIMAS Winter Olympics, "Politehnica" University of Bucharest 2010, 2011 - 2^{nd} prize.
- Summer School on Virtual Environments - 2012 to date.
  - *creatiVE*: http://creative.cerva.ro

Professional associations and PhD students

1. American Computering Machinery (ACM), 2011 - to date
2. IEEE, 2016 - to date
3. Romanian Mathematical Society (SSMR), 2005 - 2009
4. Romanian Computer-Human Interaction Special Interest Group (SIGCHI), Romania, (RoCHI), 2005 - to date

5. Member in supervising committees of 14 PhD students ("Transilvania" University of Braşov, "Politehnica" University of Bucharest, "Ştefan cel Mare" University of Suceava, Université de Bretagne Occidentale, Brest, France)

Committees

1. Organising committees of 10 international and 11 national conferences
2. Program/scientific committee or reviewer for 23 international and 22 national conferences
3. Member of scientific/editorial committee or reviewer for 2 ISI, 4 BDI and 1 non-indexed international journals

Future work (I)

- Programming, Computer Graphics, AI-oriented Techniques, Natural Multimodal Interfaces, Mechatronics
- Continuous Updating MVMOD suppport (paper+online)

- Introducing modularity for mobility
- New specialisation : Computers and Information Technology
- Bussiness partners involvement in educational act
- Students implication in research projects (bachelor, master, PhD)

Research activities

Modeling the space in virtual universes

Model for virtual environment

Usable in VR applications

Modeling the space in virtual universes

Model for virtual environment

Usable in VR applications

Structural

- formal
- semantic

Modeling the space in virtual universes

Model for virtual environment

Usable in VR applications

Structural

- formal
- semantic

Behavioral

- formal
- semantic
- animation

Modeling the space in virtual universes

Model for virtual environment

Usable in VR applications

Structural

- formal
- semantic

Behavioral

- formal
- semantic
- animation

Interactional

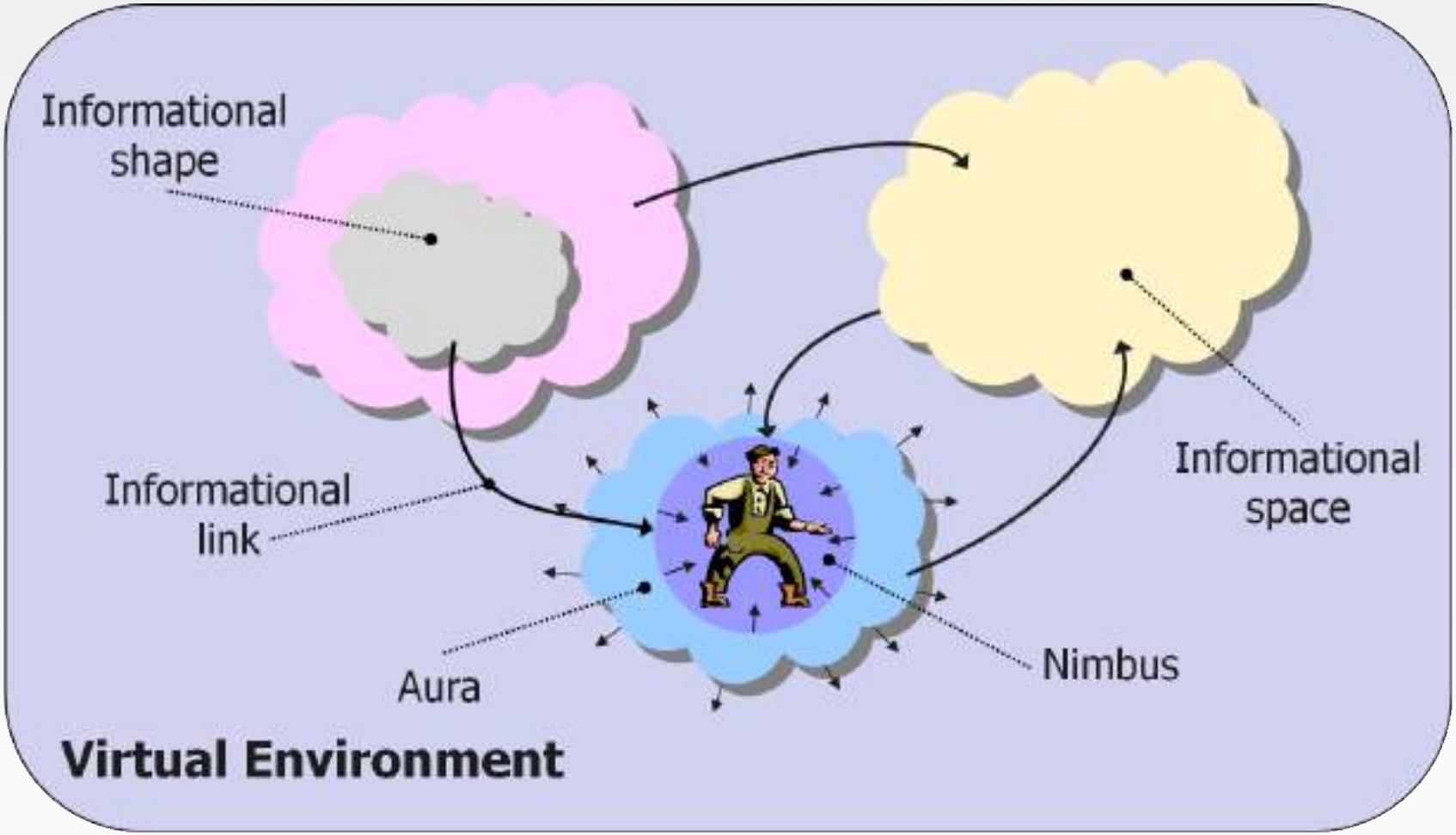
- navigation
- interaction

Model for virtual environment

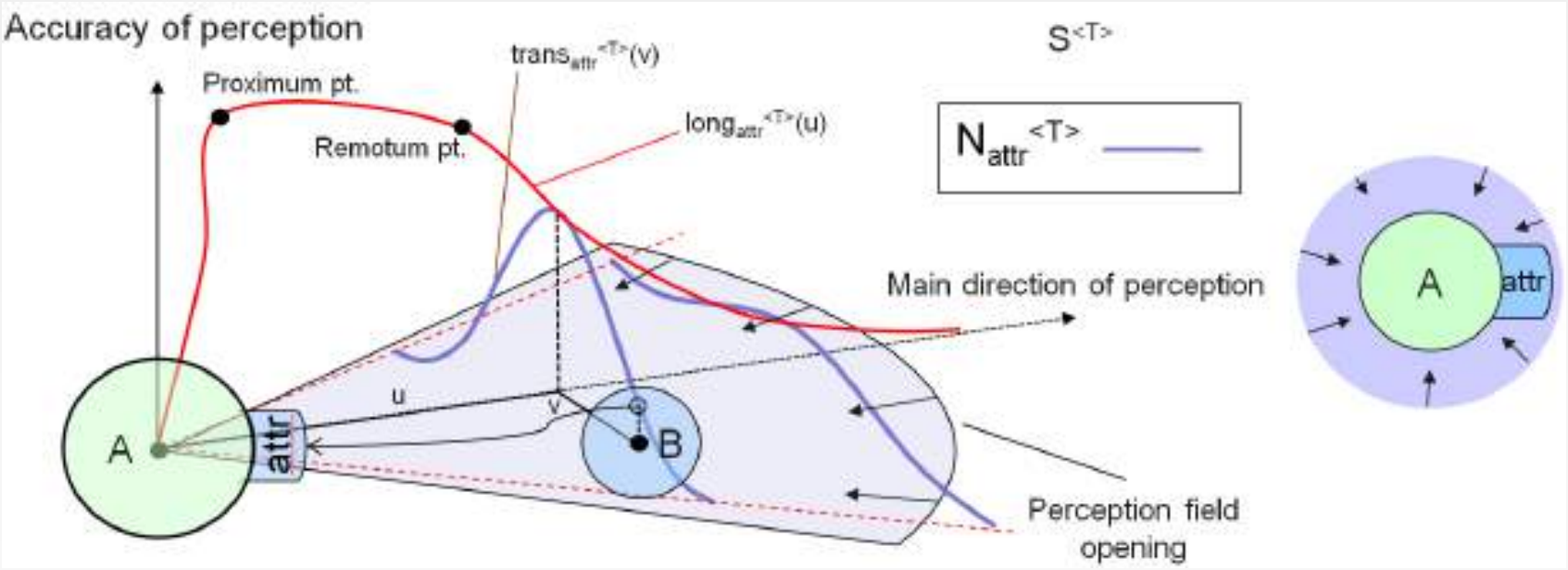
Structural view

User's setting into situation

VE's internal organisation - informational space

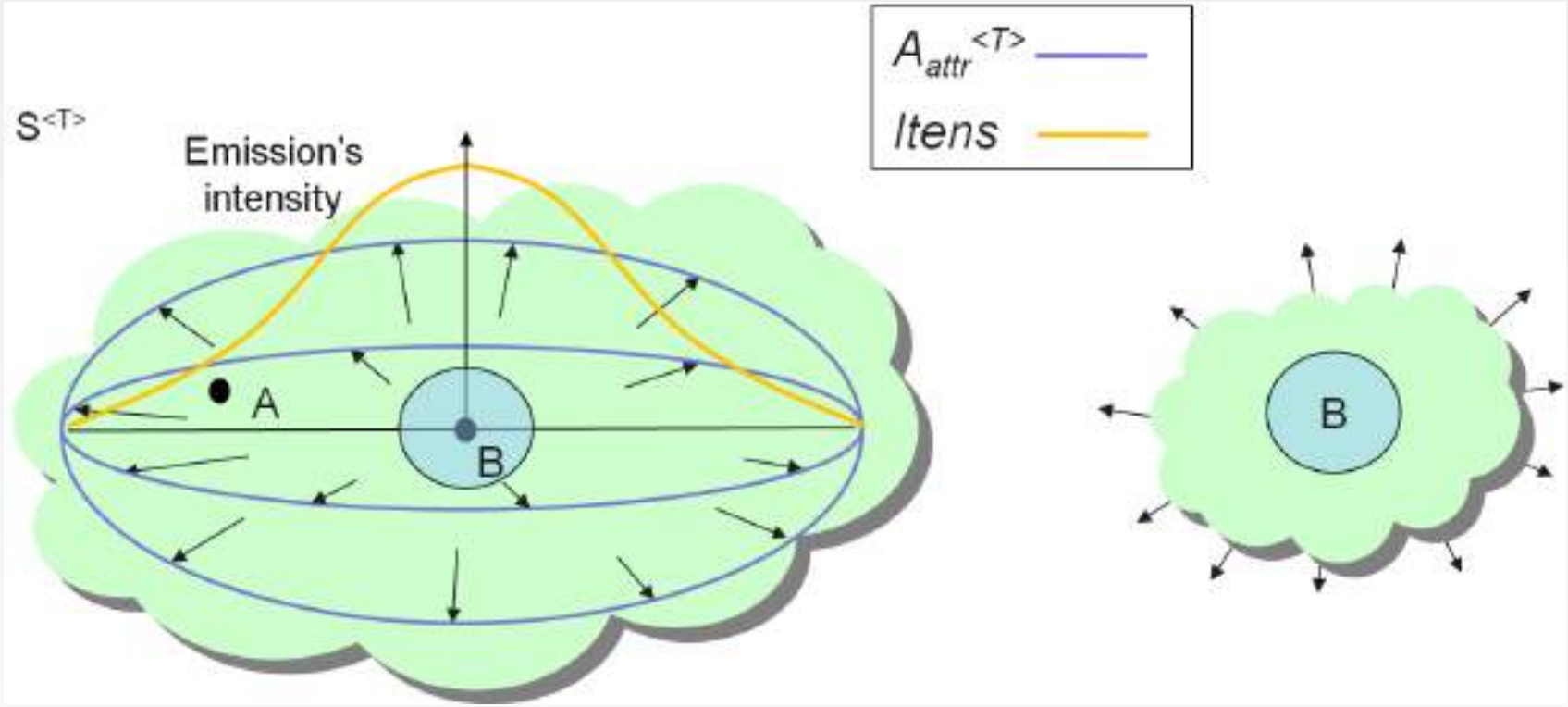


VE's internal organisation - Nimbus



$$N_{attr}^{<T>} = \left\{ x \in R^3 \;\middle|\; \mu_{attr}^{<T>} > 0 \right\} \quad (1)$$

VE's internal organisation - Nimbus & Aura



$$A_{attr}^{<T>} = \left\{ x \in R^3 \;\middle|\; itens_{attr}^{<T>}(dist(x_B, x)) > 0 \right\} \qquad (2)$$

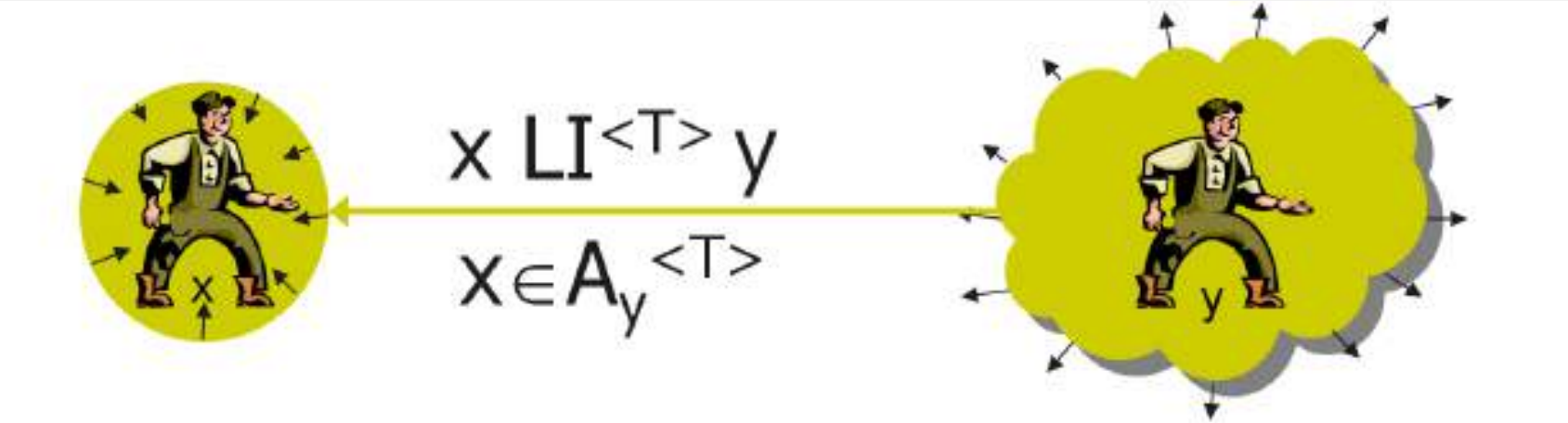
VE's internal organisation - informational shapes

$< x, T, A_x^{<T>} >$

$> x, T, N_x^{<T>} <$

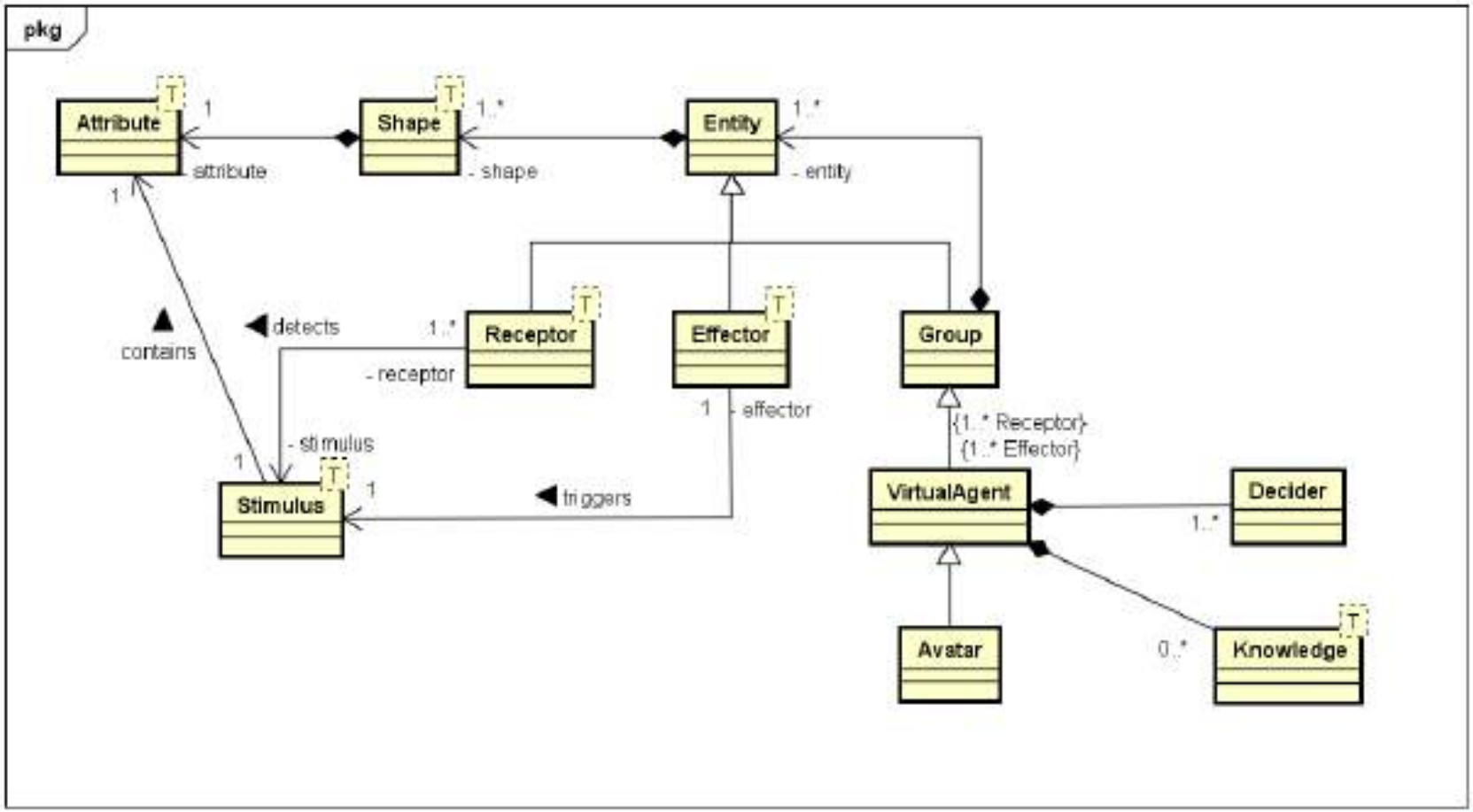
$> x, T, N_x^{<T>}, A_x^{<T>} >$

VE's internal organisation - informational shapes & links



$$x\ LI^{<T>}y = \mu_x^{<T>}(y) \cdot itens_y^{<T>}(x). \quad (3)$$

VE's internal organisation - agents



VE's internal organisation - results - publications

175 Popovici, D. M., Şerbănaţi, L. D., Chevaillier, P., Morvan, S., and Tisseau, J. *A Model-Driven Architecture for VR Agents*. In Proceedings of VRIC 2005 (Laval, France, 2005), pp. 65-74.

177 Popovici, D. M., Şerbănaţi, L. D., and Gerval, J. *Agent-based modeling of virtual environments*. In Proceedings of VRIC 2003 (Laval, France, 2003), pp. 149-158.

178 Popovici, D. M., Şerbănaţi, L. D., and Gerval, J. *Virtual perception based agents in virtual theater*. In Proceedings of Technologies for Interactive Digital Storytelling and Entertainment (TIDSE'2003) (Darmstadt, 24-26 March 2003, Germany, 2003), pp. 94-105.

179 Popovici, D. M., Şerbănaţi, L. D., and Harrouet, F. *The virtual environment - another approach*. In WSCG'2003 Posters Proceedings (Plzen, Czech Republic, 2003), pp. 109-112.

VE's internal organisation - results - projects

P6 REVE - Renforcement EVE - Environnements Virtuels pour Enfants - Fonds Francophones des Inforoutes, ENIB/CERV, France - Scientific manager (2003-2005)

P5 PHARE CBC 2005 Romania-Bulgaria, Contract no : RO2005/017-535.01.01: People to people "Venus la Dunarea de Jos" - Scientific director (2008-2009)

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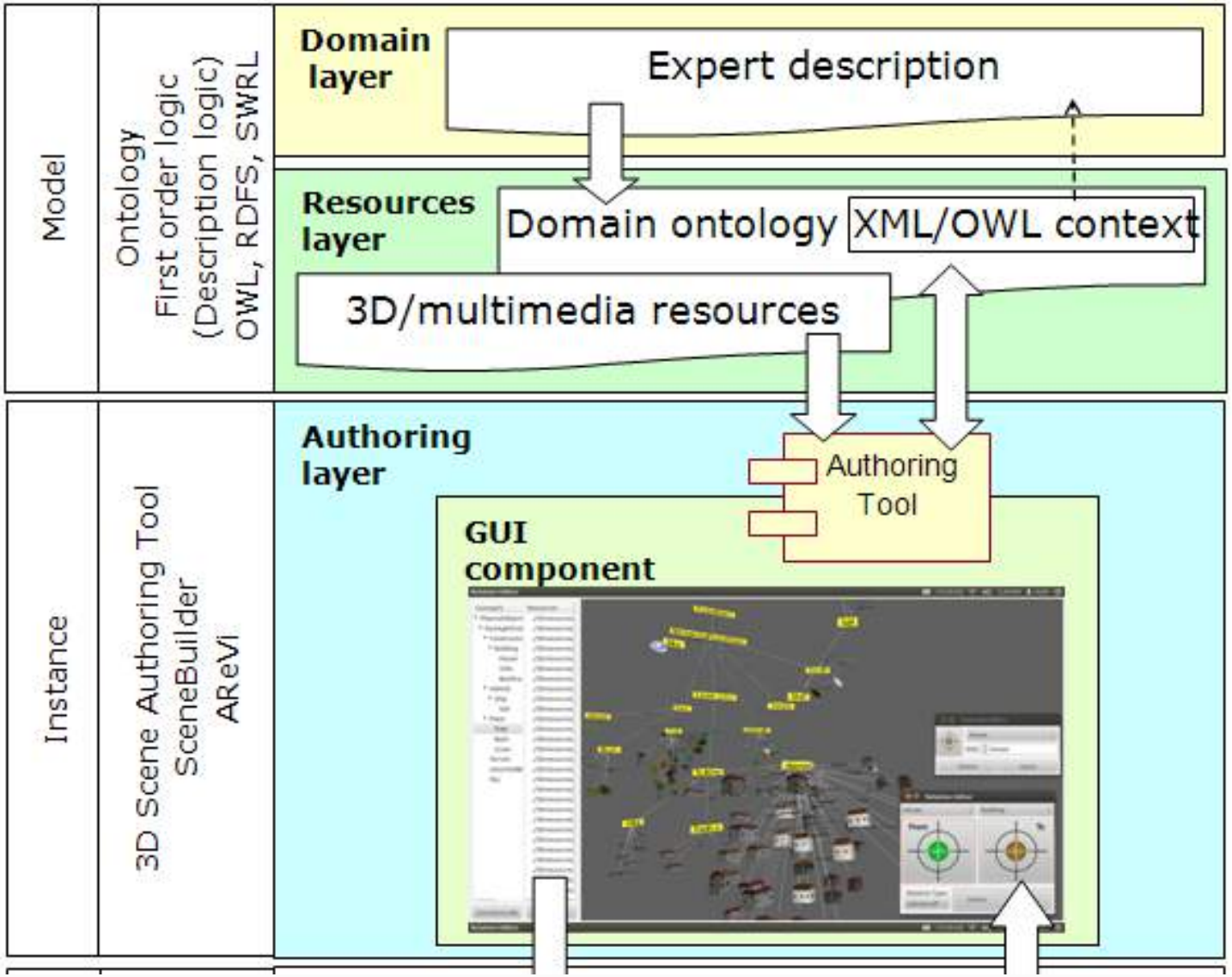
VE's internal organisation += semantics



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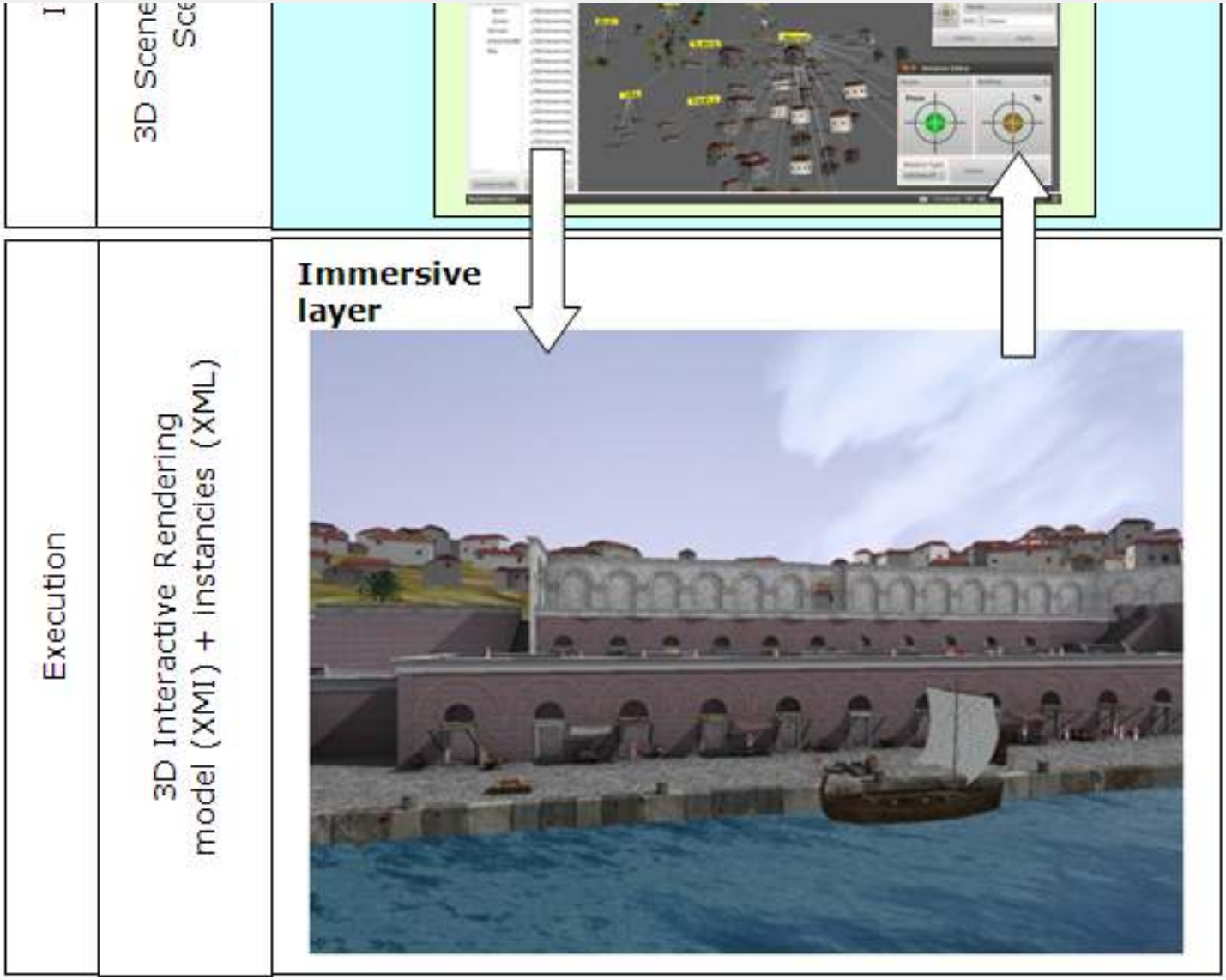
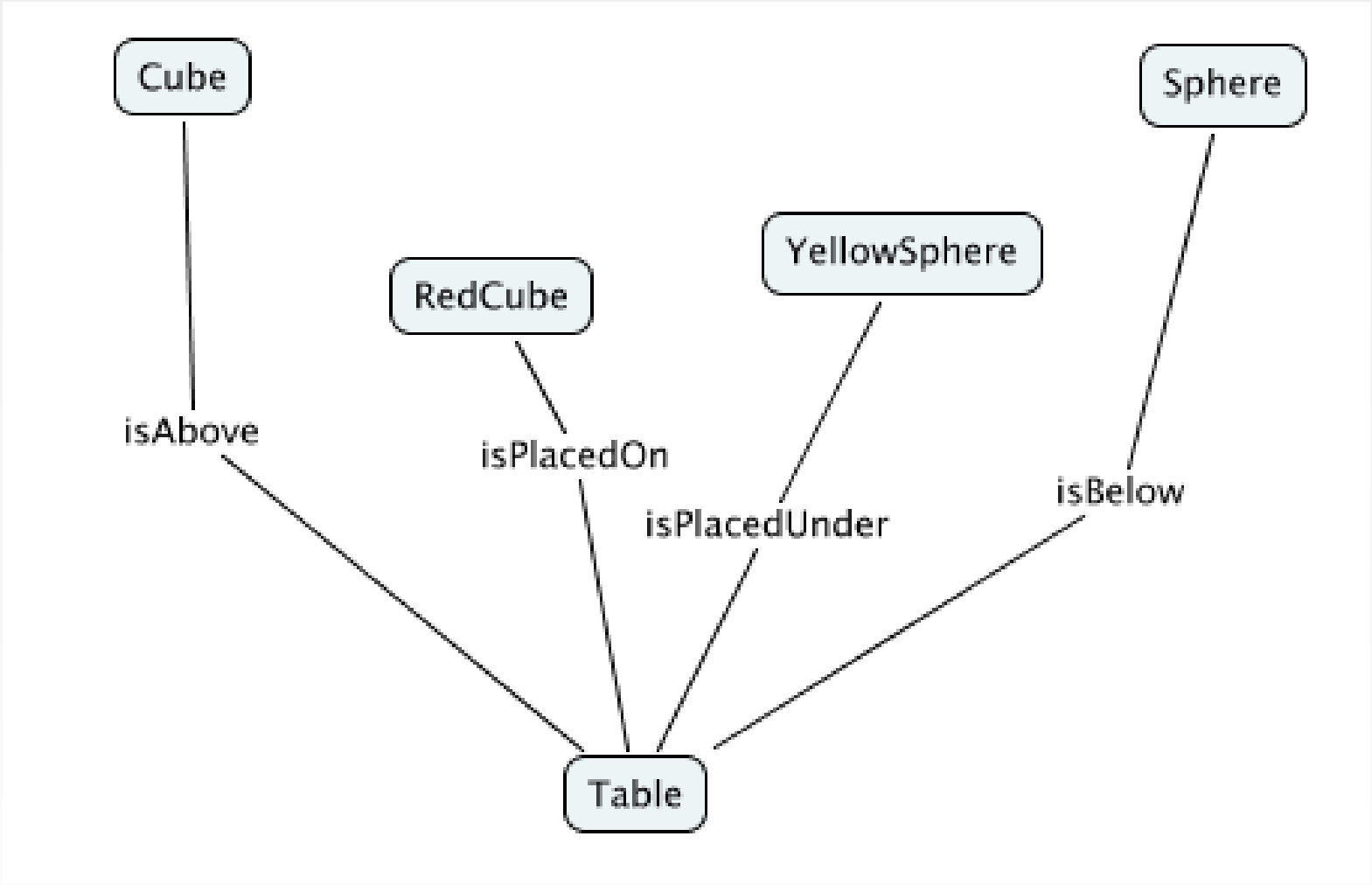


Artifacts' semantics at work



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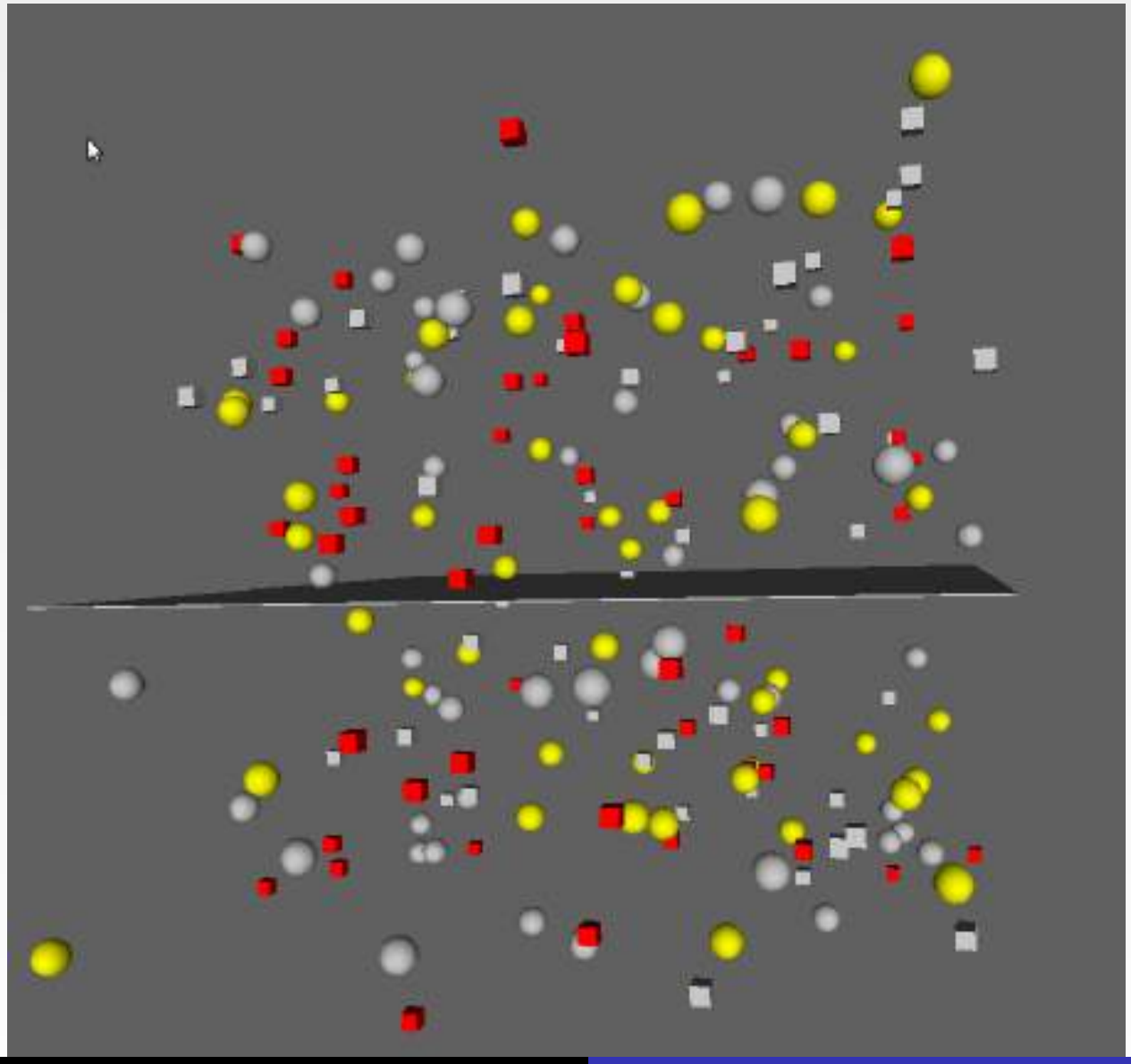

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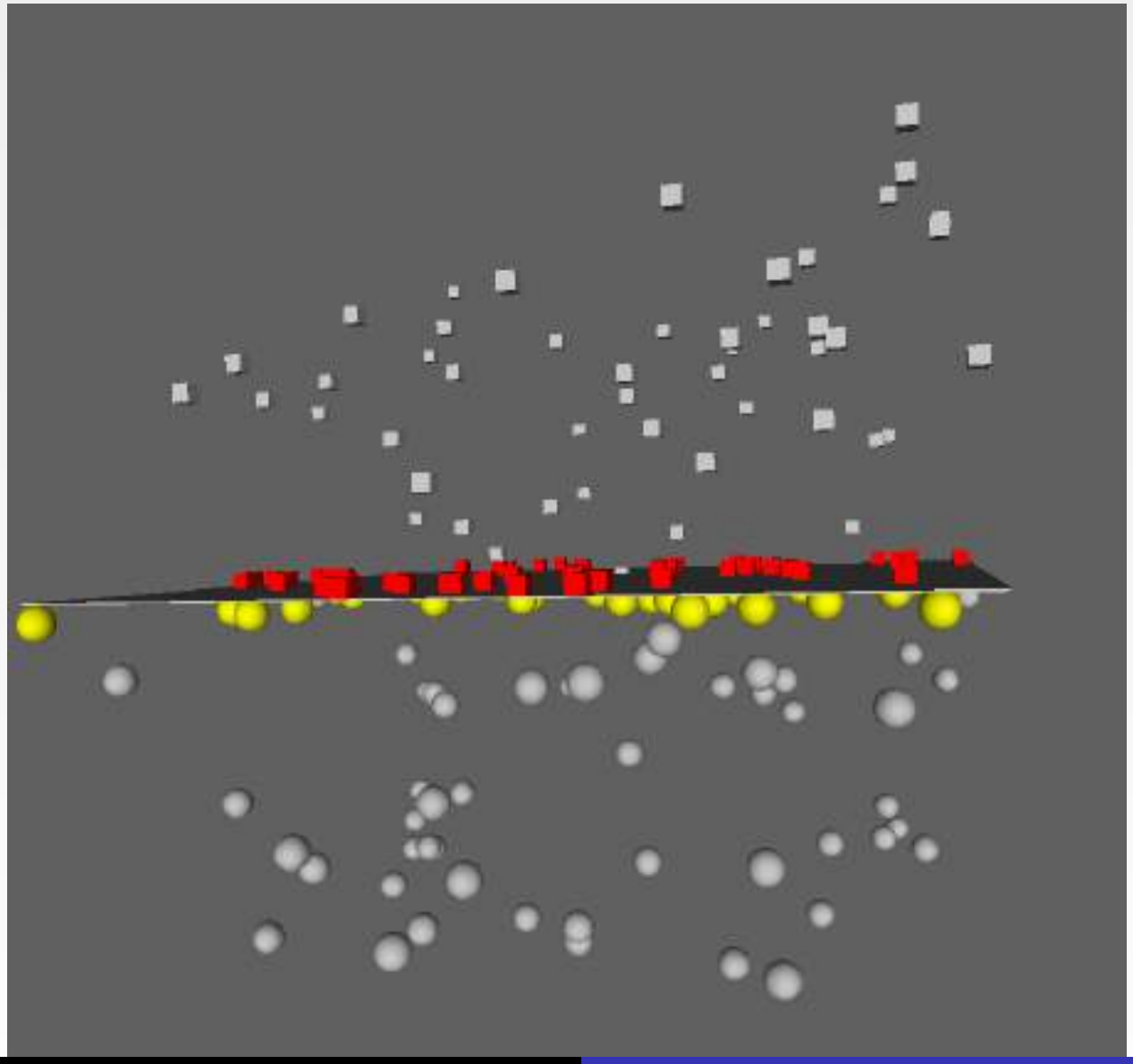

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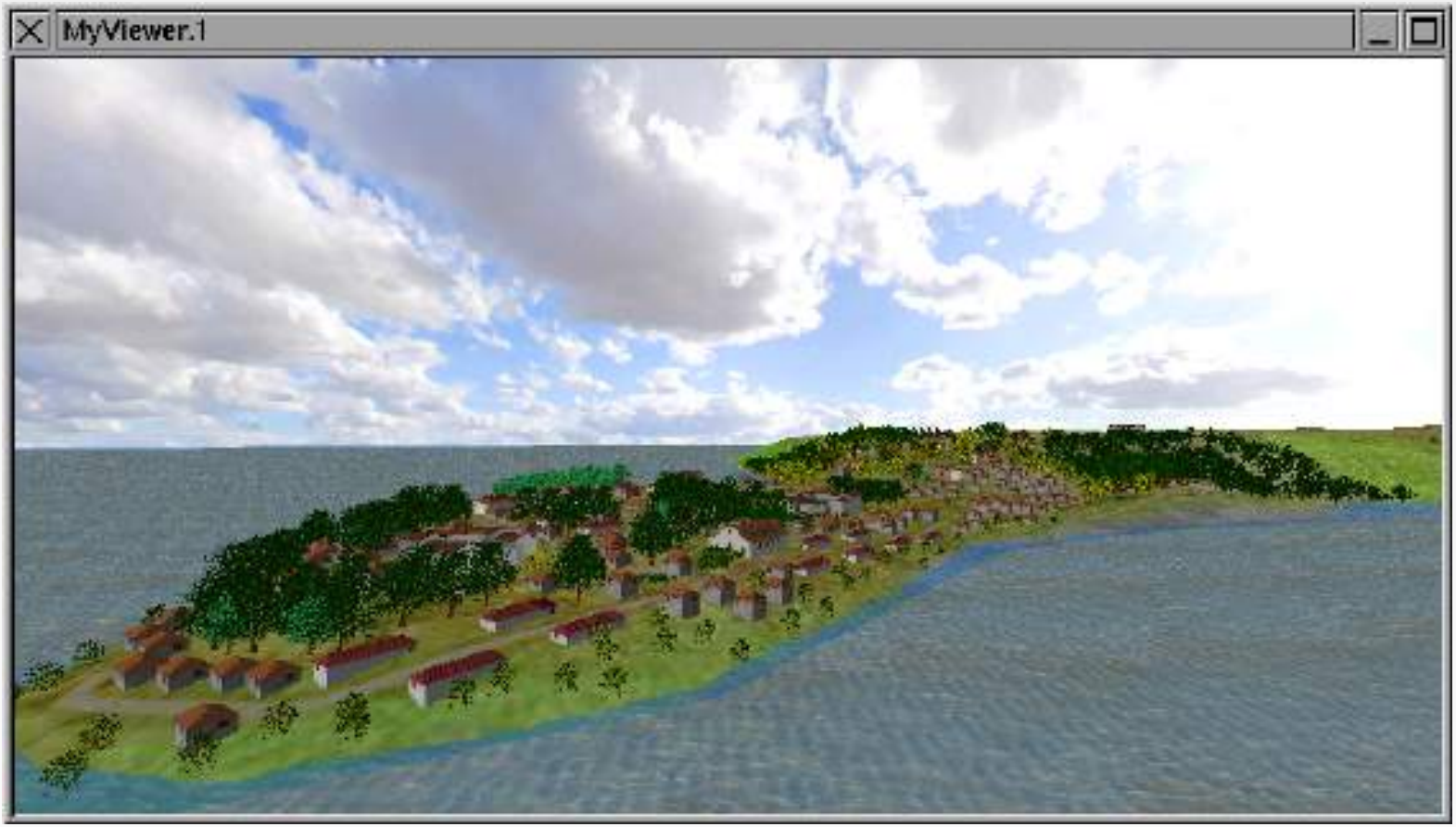


VE's internal organisation - results - publications

27 Bogdan,C.M., Popovici,D.M. *Authoring tool for narrative-oriented educational virtual environments using ontologies*. Proc. of the 10th VRIC(2008), pp.109-115.

28 Bogdan, C.M., Popovici, D.M. *Domain ontology-based management of virtual scenes*. In Proceedings of the 12th WSEAS international conference on Mathematical methods, computational techniques and intelligent systems (2010), WSEAS, pp. 125-130.

29 Bogdan, C. M., Popovici, D. M. *The use of domain ontologies for the virtual scenes management*.WSEAS Transactions on Computers 9,8(2010),pp.868-877.

156 Popovici, D. M., Bogdan, C., and Querrec, R. *Ontology based modeling of cultural heritage systems*. In Proceedings of the 10th International Conference on Development and Application Systems (2010), pp. 376-381.

157 Popovici, D.M., Bogdan, C.M., Matei, A., Voinea, V., Popovici, N. *Virtual heritage reconstruction based on an ontological description of the artifacts*. Int. J. of Computers, Communications and Control Suppl. issue: Proceedings of ICCCC, Vol. III (2008), 460-464.

150 Polceanu, M. *Semantic resource management, reuse and validation in 3D virtual environments*. Master's thesis, Ovidius University of Constanta, Romania, 2012. Coord. Popovici, D.M.

VE's internal organisation - results - projects

[P1] 11-041/2007 "Using virtual reality in 3D multimodal reconstruction of historical sites: TOMIS", dir.(2007-2010)

VE's internal organisation - results - projects

[P7] Research grant PROMETEU - Prototypage d'environnements virtuels informee pour la museologie, AUF, (2010), Universite Bretagne Occidentale, Brest, France.

Structural view on VE - a step forward

Informational link of the VE with the Internet of Things (IOT)

- Stimuli triggered in the virtual environment of ”things” by sensors placed in the real environment helps in state updates of virtual replica of simulated real environments.

Applications:

- Preventions of environmental disasters or ecological recovery.

Structural view on VE - one more step forward

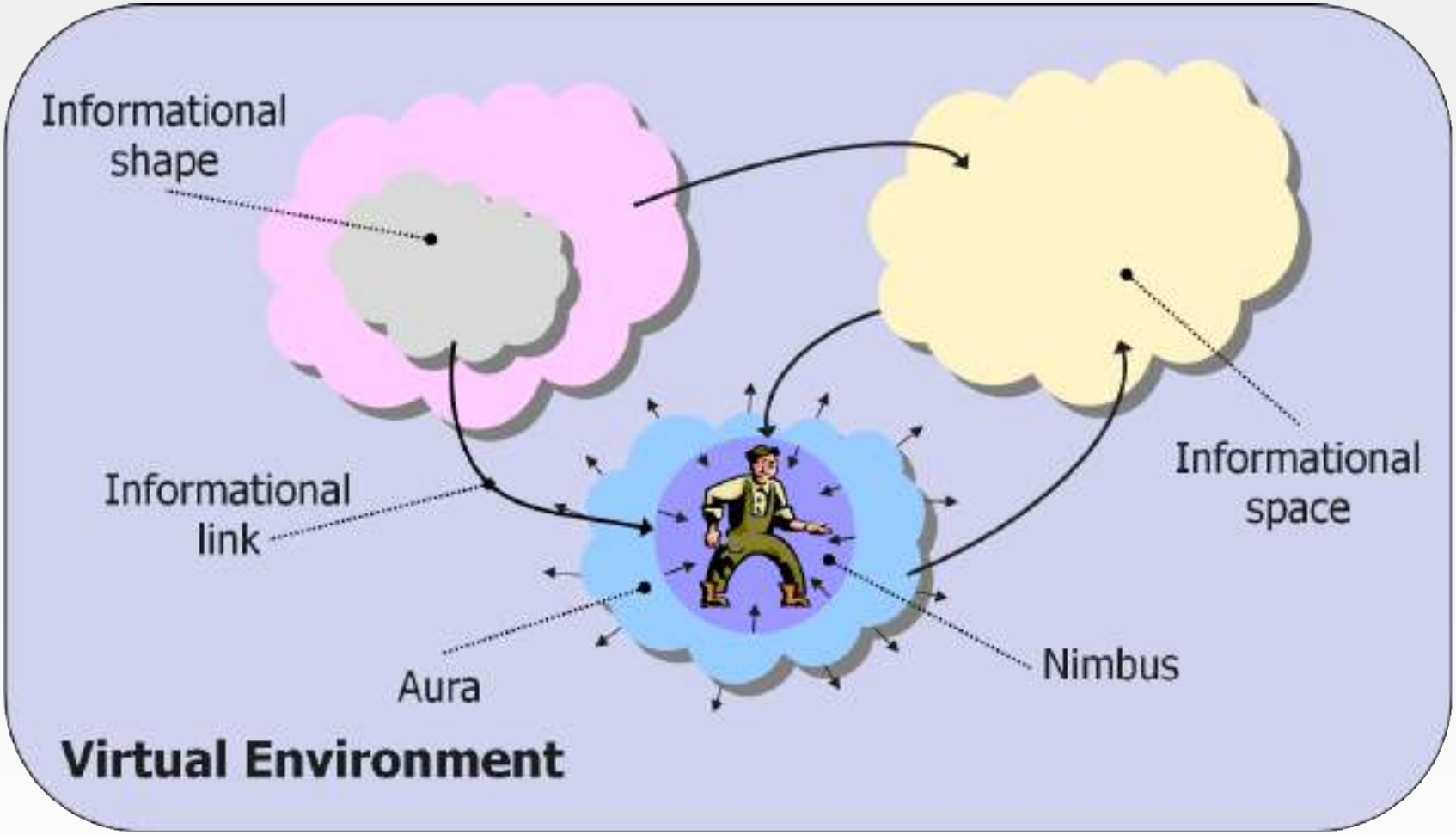
Designing and developing of an adaptive, evolutive and emotionally responsive artificial intelligence system interconnected with the key structure points of the IOT paradigm

- A more human-oriented ”interface” that offers an adaptive, evolutive, and interactive multimodal representation of already existed stored data and that may be interactively used in order to interogate, modify or update IOT data.

Model for virtual environment

Behavioral view

VE's internal organisation: VE=(AG,ST)



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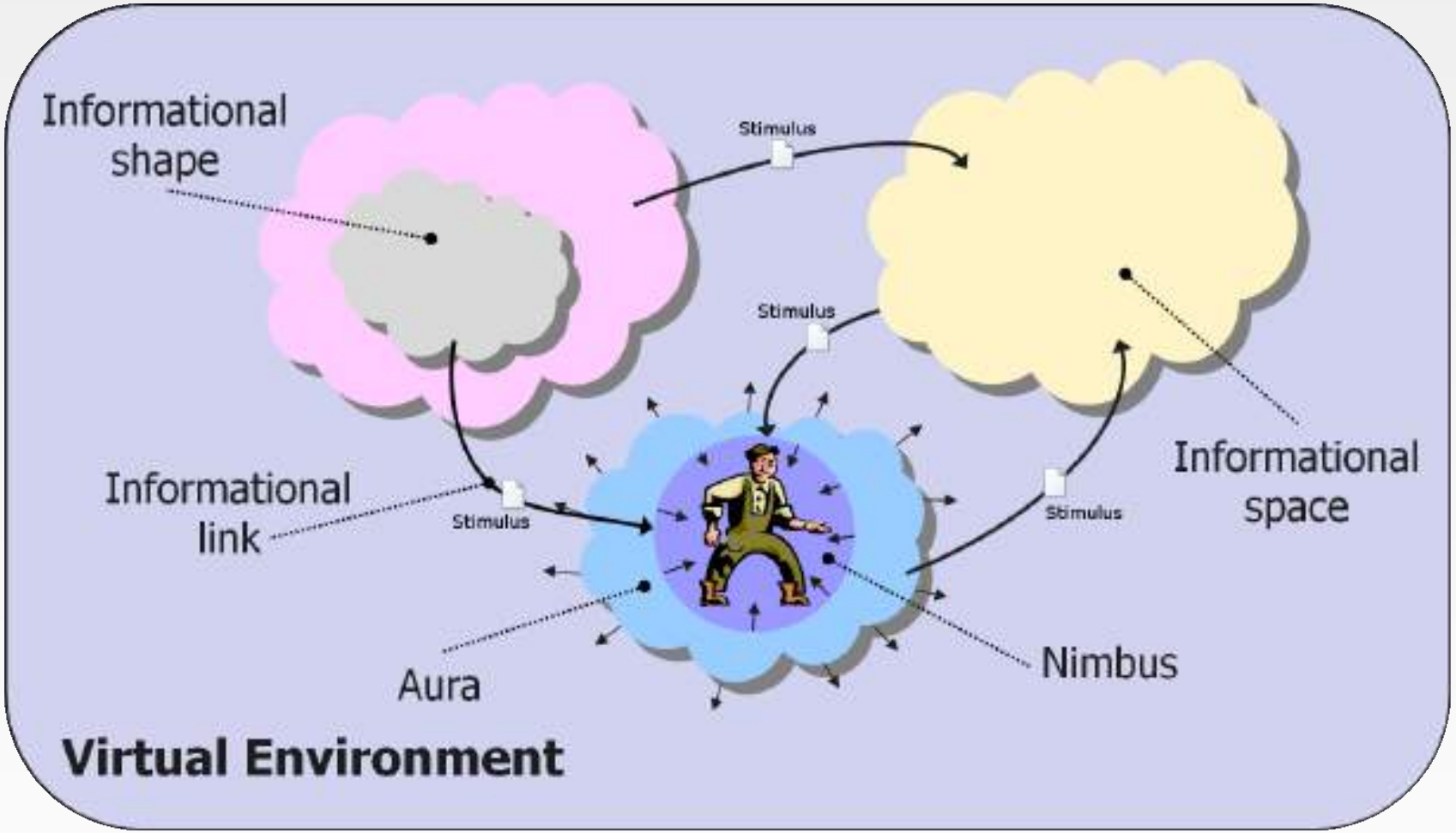
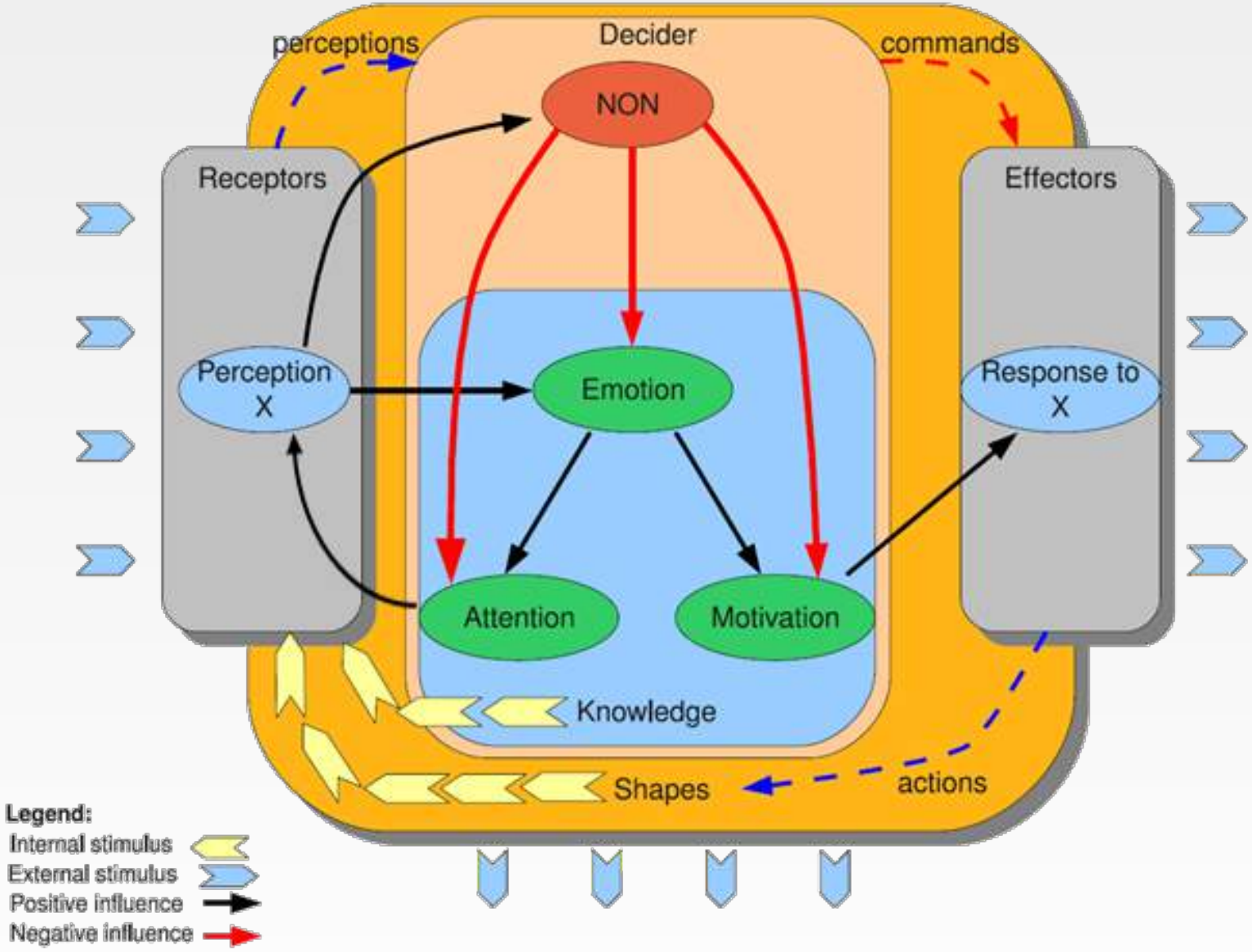
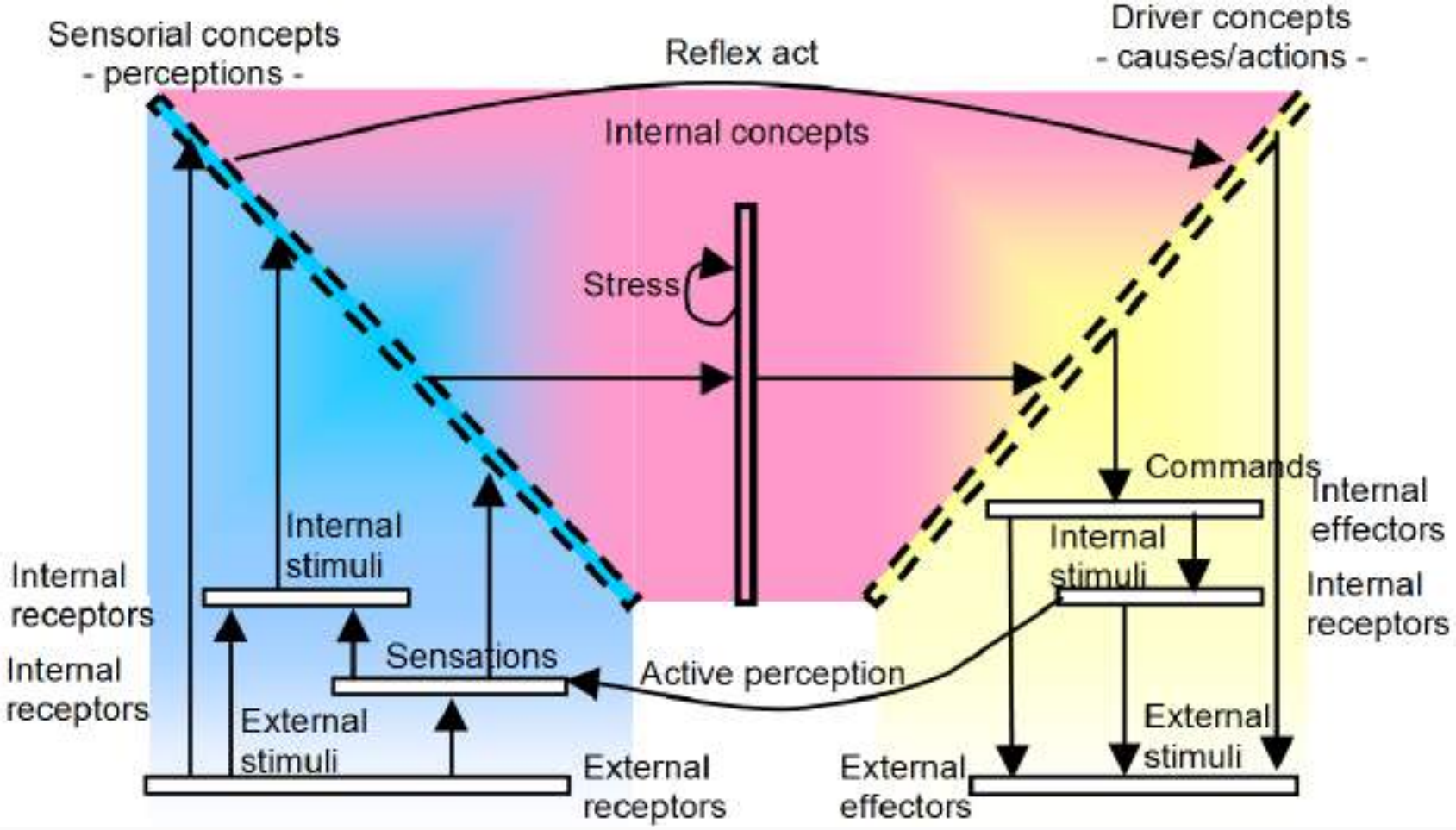


VE's evolution - agent view



Reaction paths



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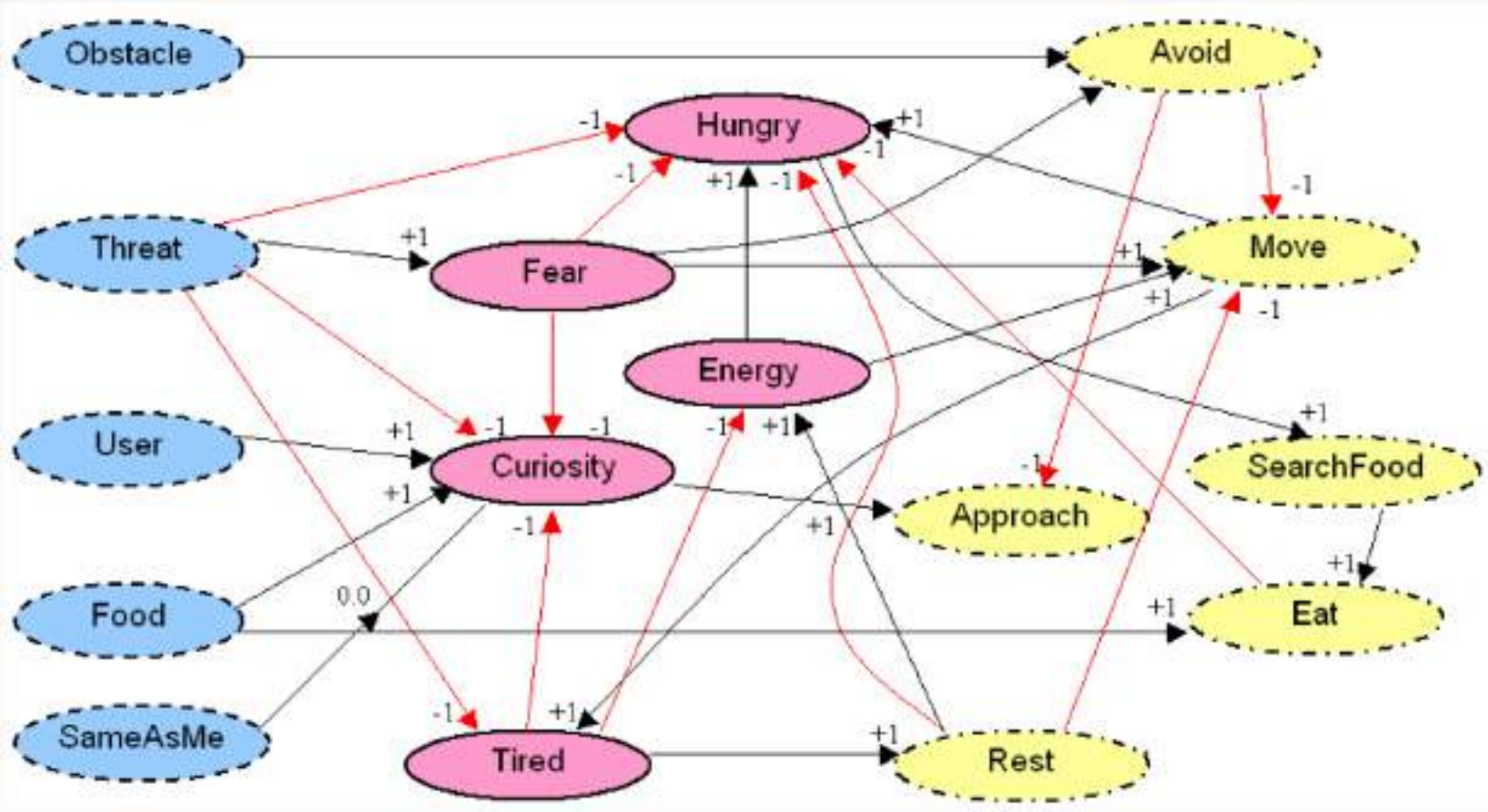
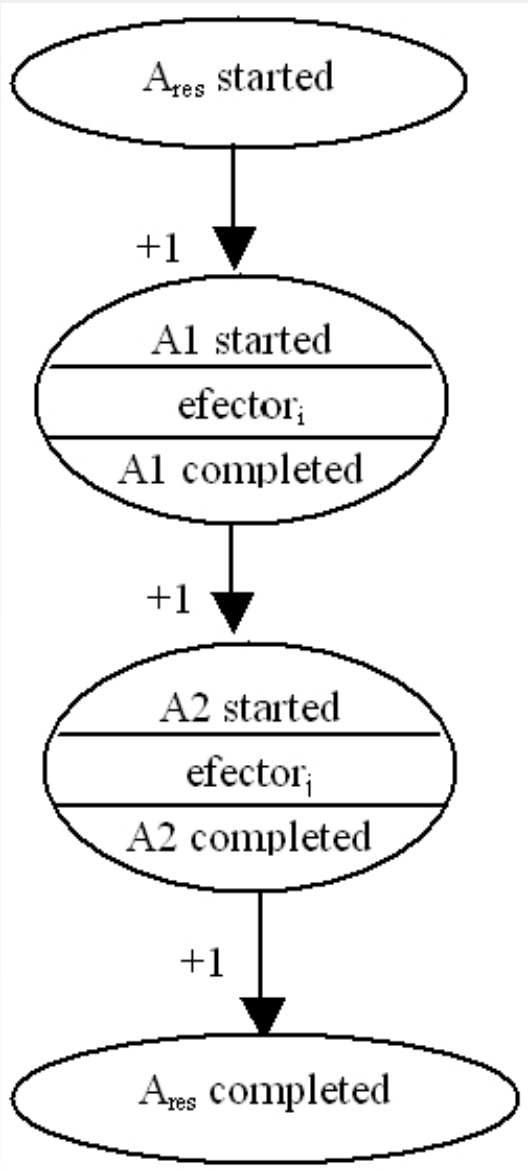


Behavioral patterns: SEQ, ALL, FOF



- SEQ
- ALL
- FOF

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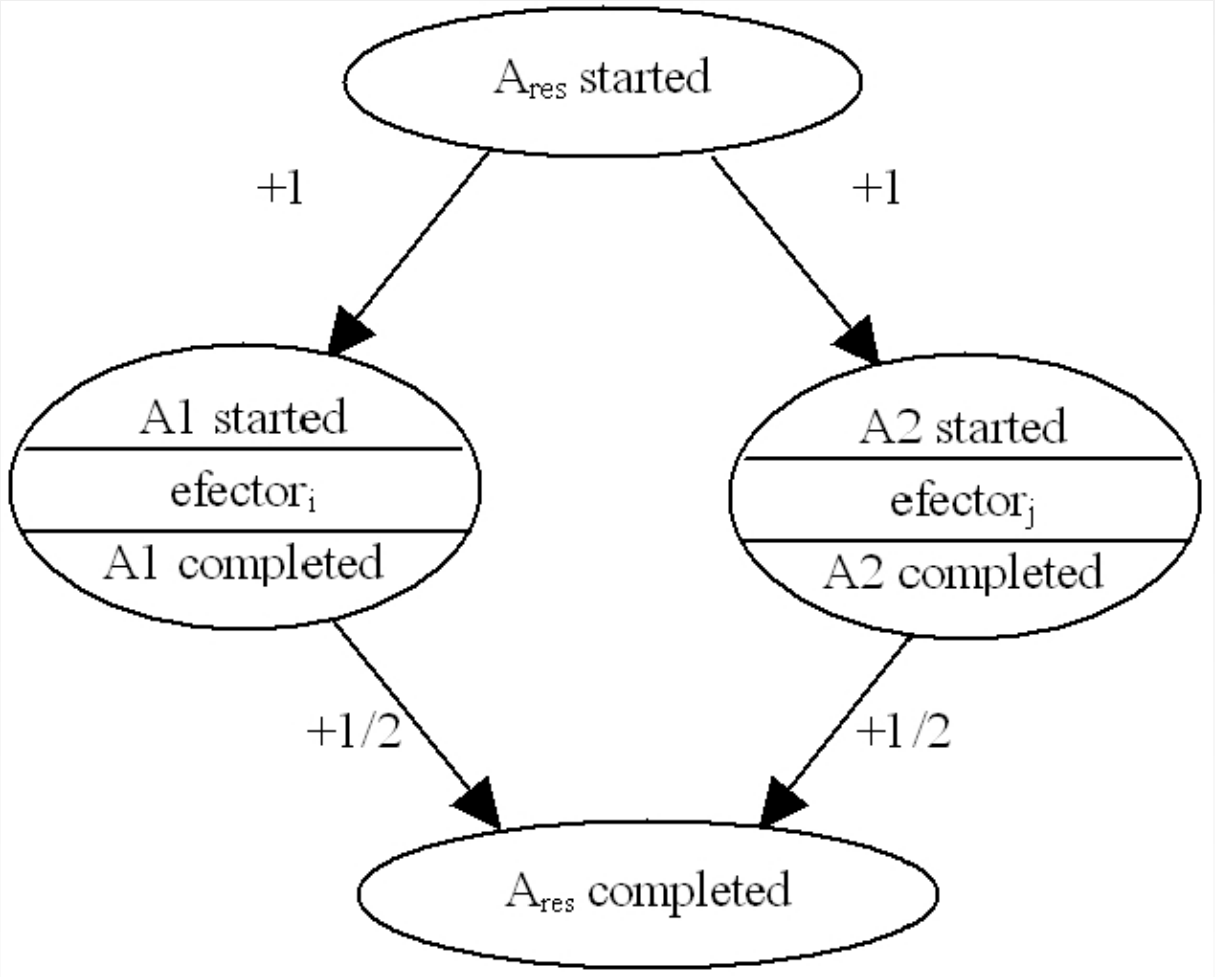

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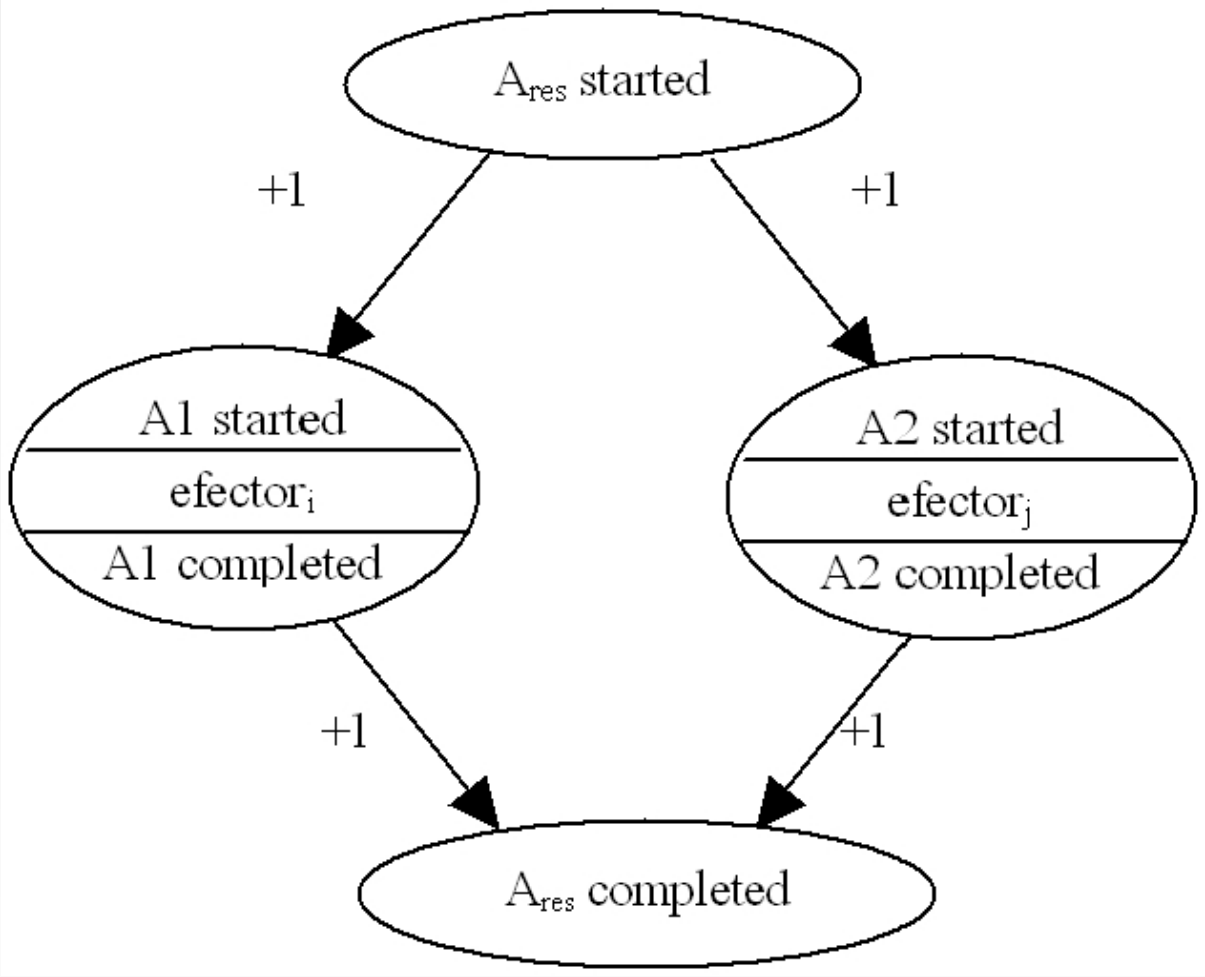
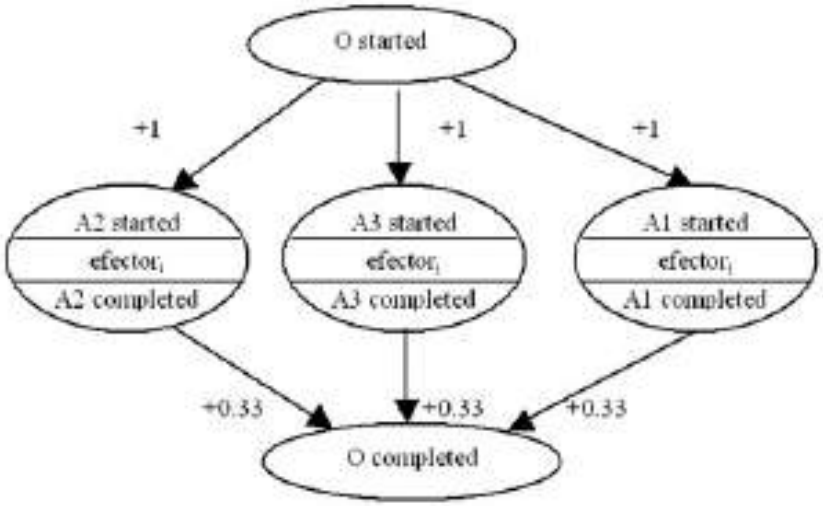


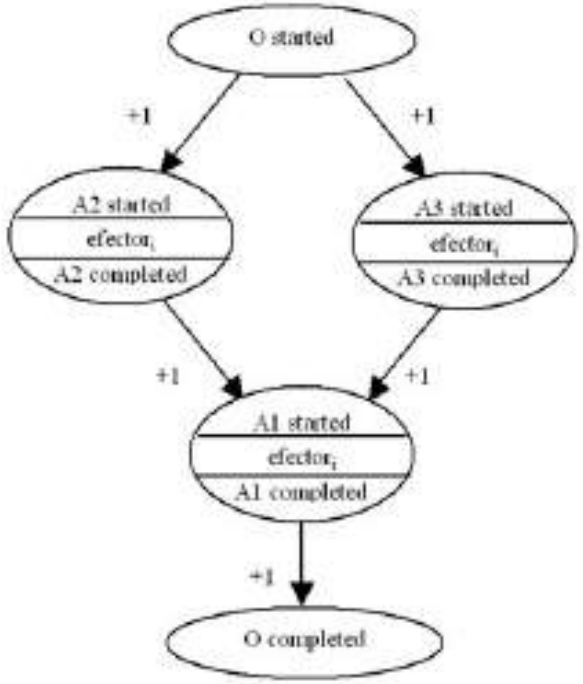
- SEQ
- ALL
- FOF

...action!

- O=leave the room
- A1=approach to the door
- A2=take the key
- A3=take the coat
- O=SEQ(ALL(A2,A3),A1)
- O=ALL(A2,A3,A1)



SEQ, FOF, ALL



Agents' life cycle

$$VE = (AG, ST). \tag{4}$$

$$AG = \{Ag_i\}_{i=1,n}, n = card(AG), \tag{5}$$

$$Ag_i = (F_i, K_i, Rec_i, Efec_i, ADec_i) \tag{6}$$

$$ST = \{st_j\}_{j=1,m}, m = card(ST) \tag{7}$$

$$\forall st_j \in ST, \exists i = 1, n,\ Ag_i \in AG, \tag{8}$$

$$\text{and } \exists k = 1, card(Efec_i),\ e_k \in Efec_i \text{ so that} \tag{9}$$

$$st_j = (e_k, \Delta s, \Delta t), \text{ and } e_k =< s, T, A_s^{<T>} > \in Efec_i. \tag{10}$$

VE's evolution - results - articles

170 Popovici,D.M., Querrec,R., Bogdan,C.M., Popovici,N. *A behavioral perspective of virtual heritage reconstruction*. Int. J. of Computers Communications & Control 5, 5 (2010), 884-891. WOS:000283908700031.

159 Popovici,D.M., Buche,C., Querrec,R., Harrouet,F. *An interactive agent-based learning environment for children*. In Proceedings of the International Conference on Cyberworlds (Tokyo, 18-20 nov., 2004), IEEE Computer Society, pp. 233-240. WOS:000225591700032.

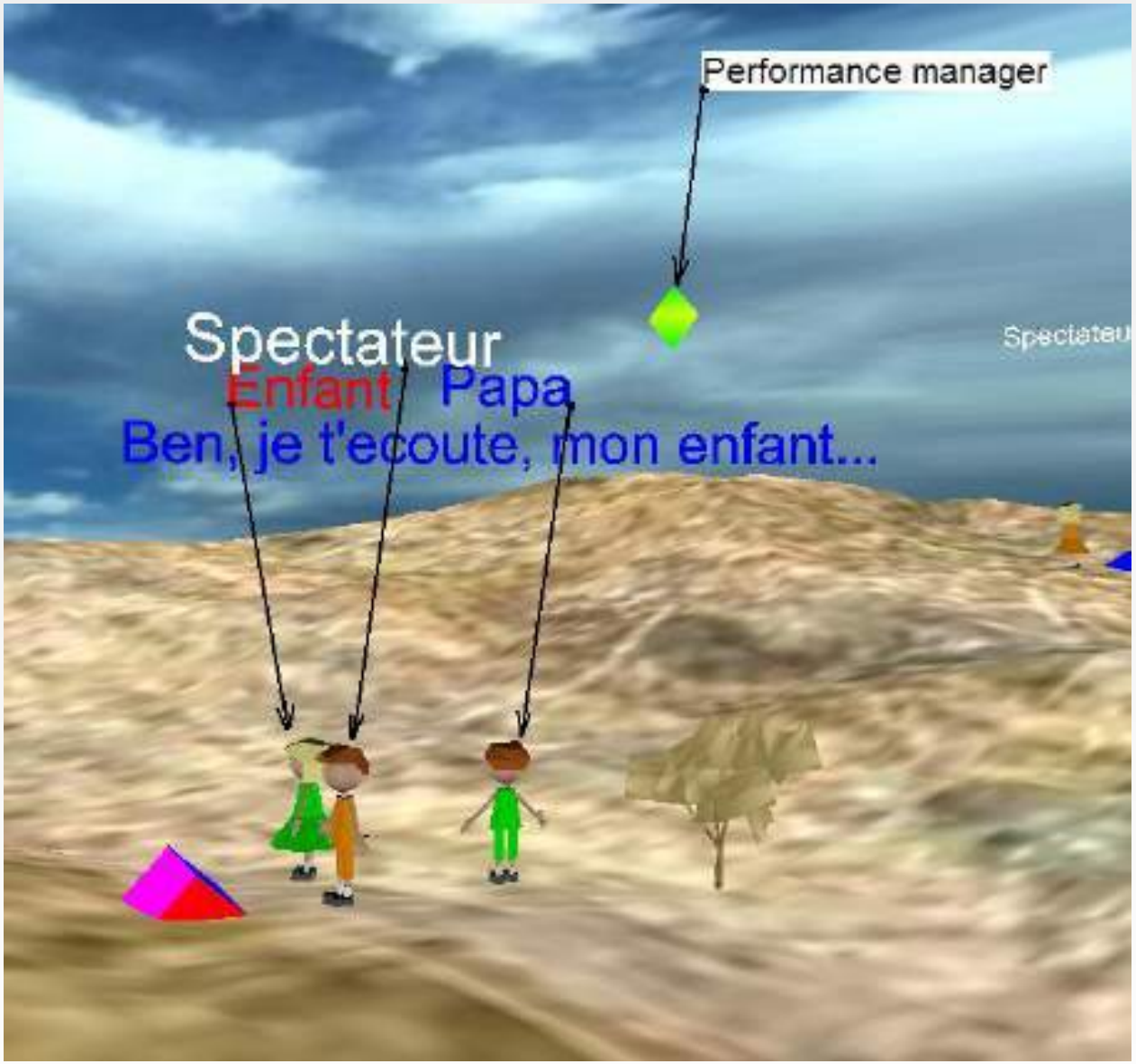
180 Popovici,D.M., Şerbănaţi,L.D., Morvan,S. *Virtual aquarium*(in romanian). In National Conference on Virtual Learning (Conferinta Nationala de Invatamant Virtual, CNIV2004) (Univ. Bucharest, 2004), pp. 167-174. (Creativity Prise).

169 Popovici,D.M., Querec,R., Harrouet,F., LeGal,C., Şerbănaţi,L.D., Morvan,S. *Virtualdive - a VR-based educational virtual environment*. (SYNASC-2005) (Timisoara, Romania, September 25-29, 2005).

VE's evolution - results - projects

- virtual theater
- virtual acquarium
- virtual guide

P1 Tomis : virtual society



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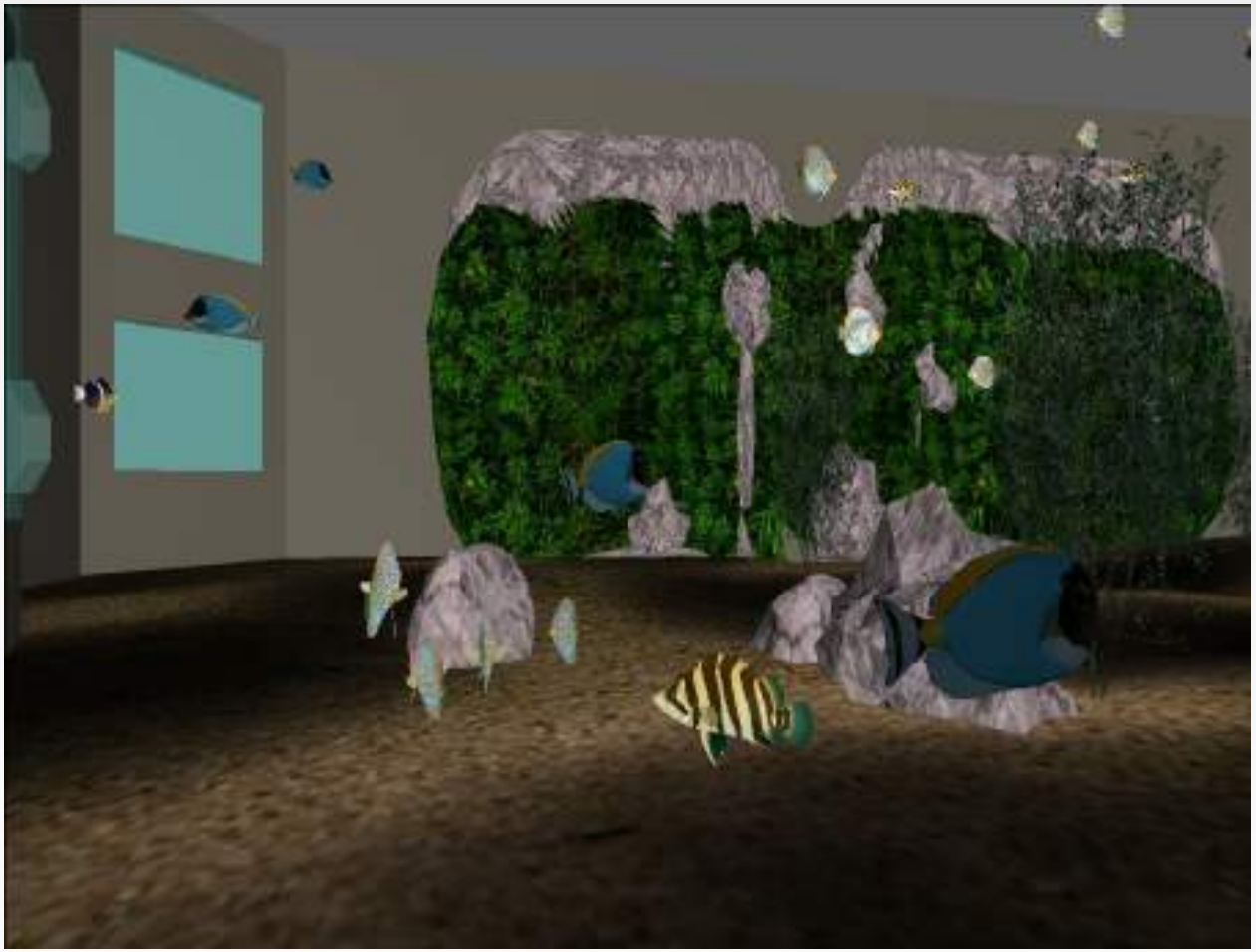

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- virtual theater
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P1 Tomis : virtual society

VE's evolution - results - projects

- virtual theater
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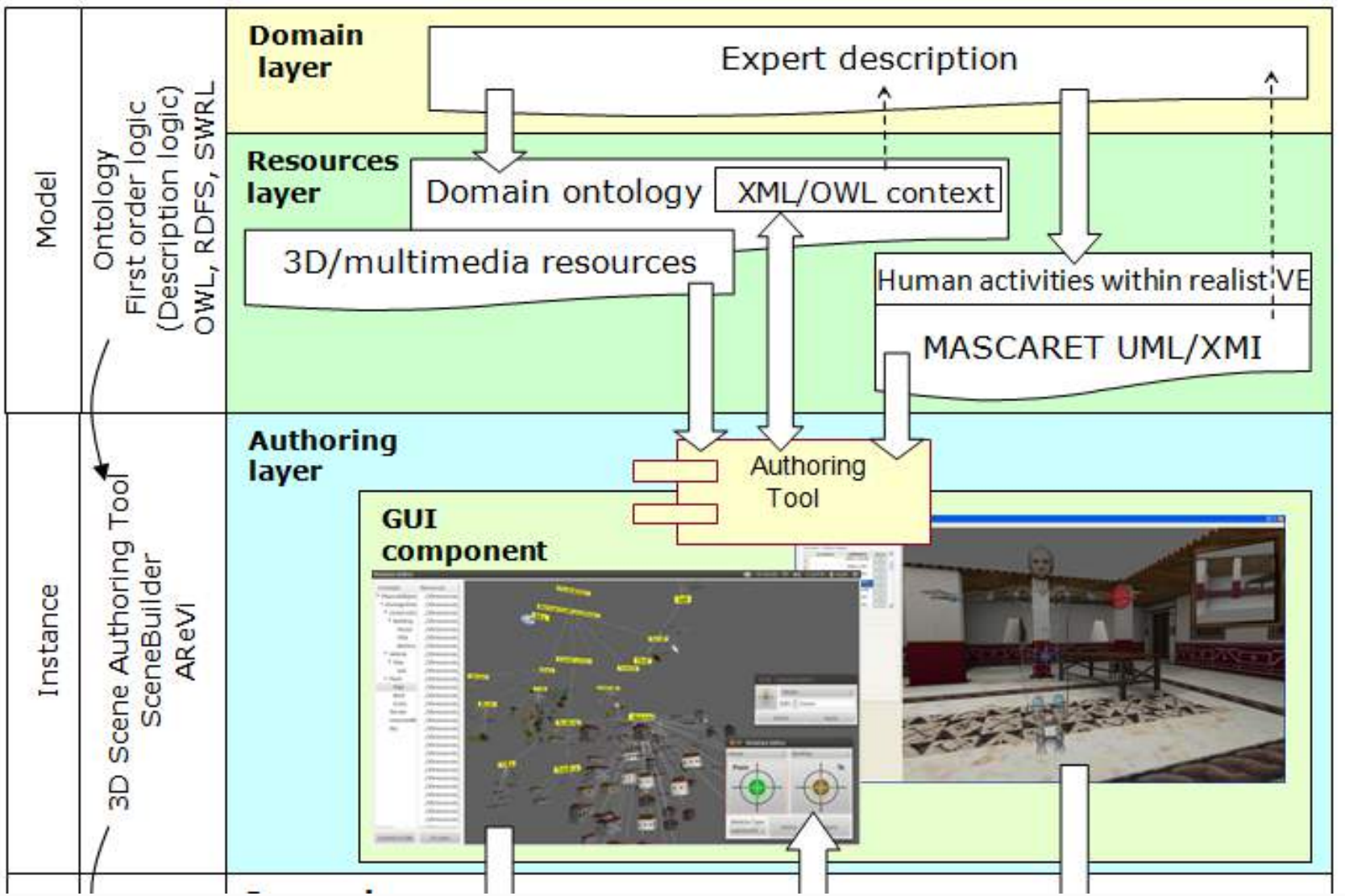
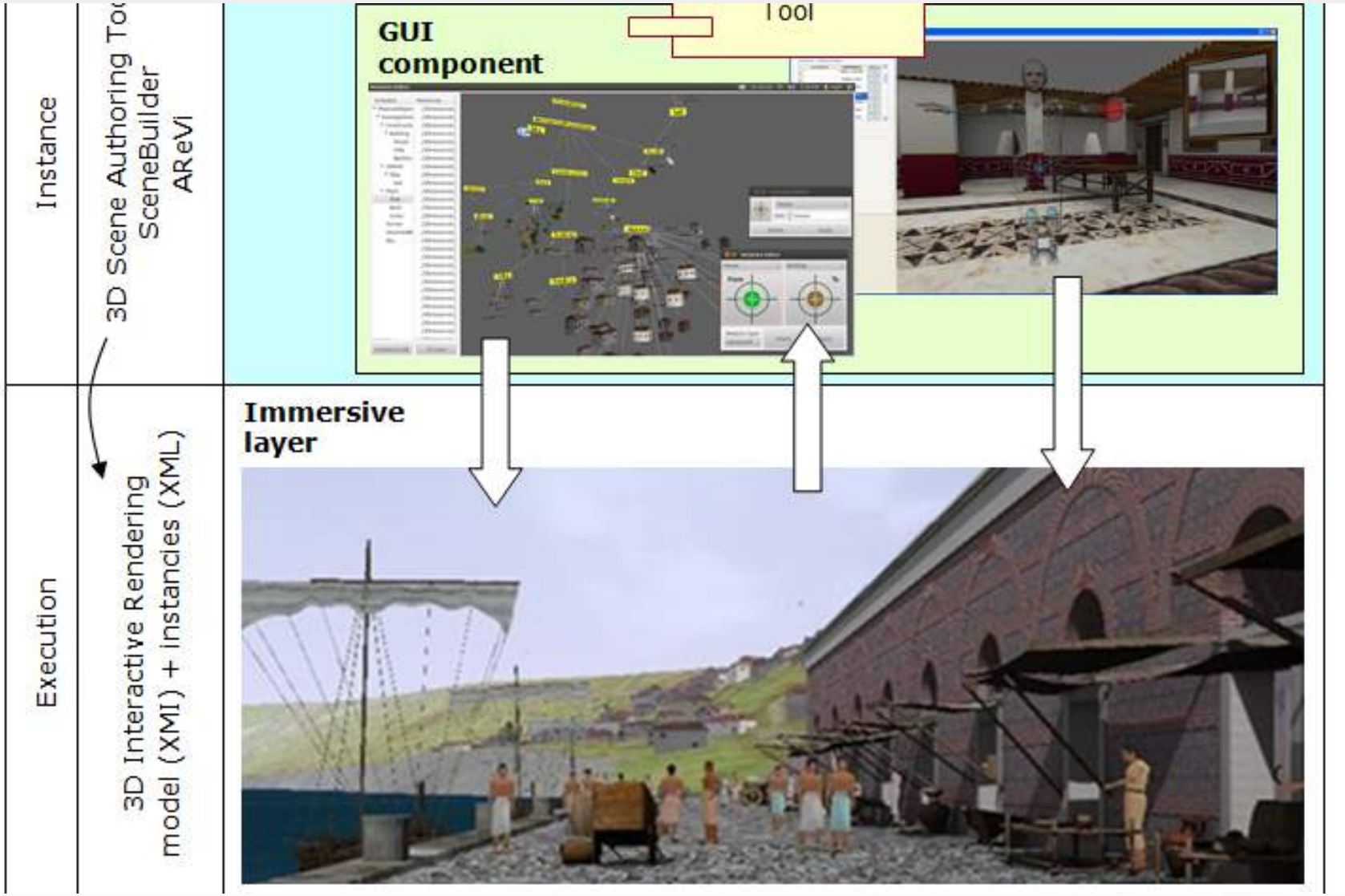
P1 Tomis : virtual society

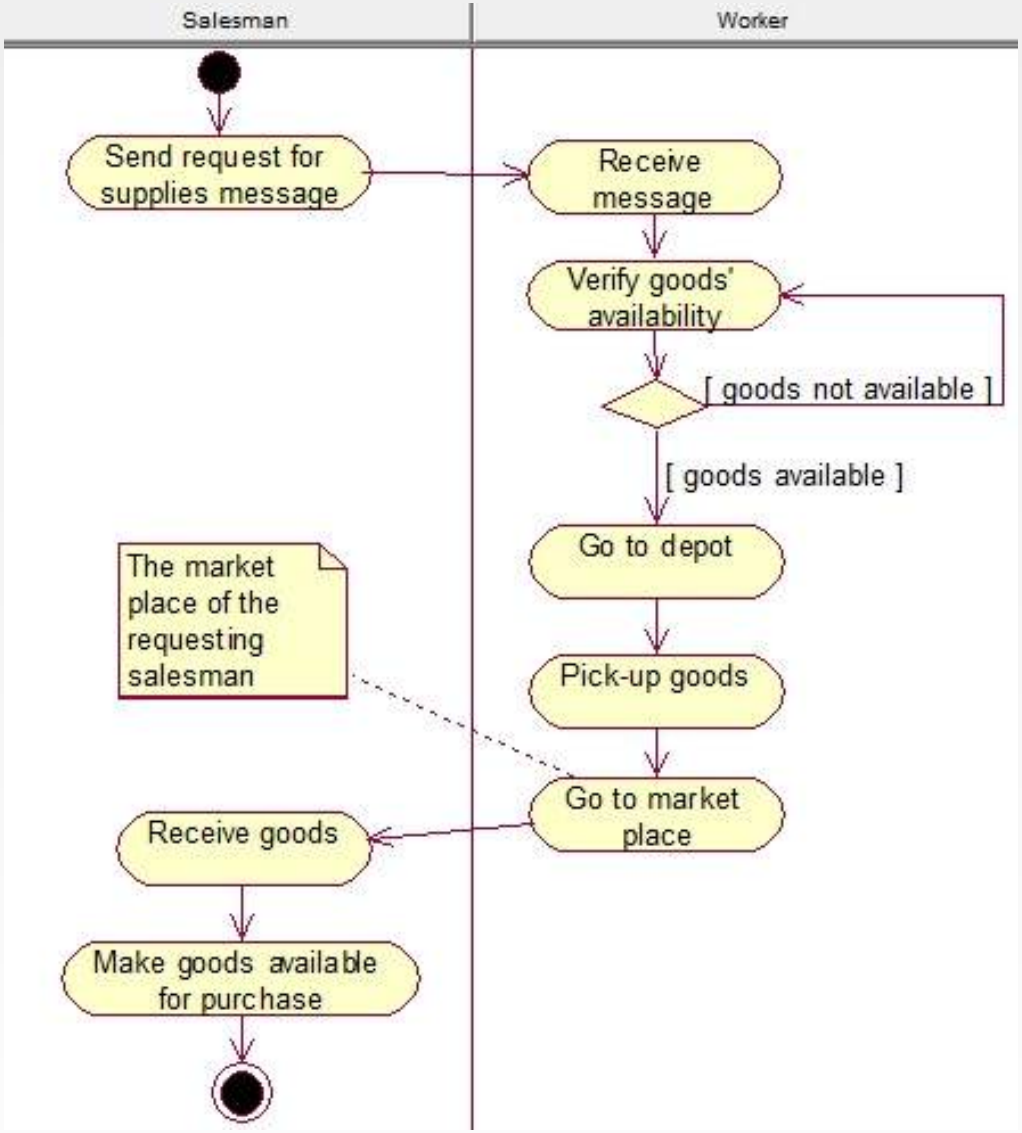
VE's evolution += semantics



VE's evolution += semantics



VE's evolution - results



VE's evolution - results

Idle | Walk | Reach out and grab an object

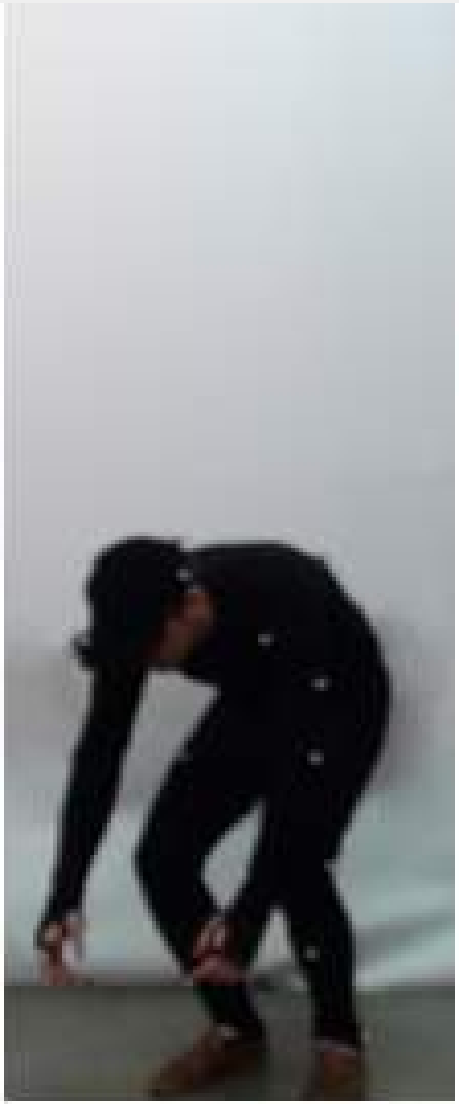
VE's evolution - results

Lift an object

VE's evolution - results

Carry an object

VE's evolution - results



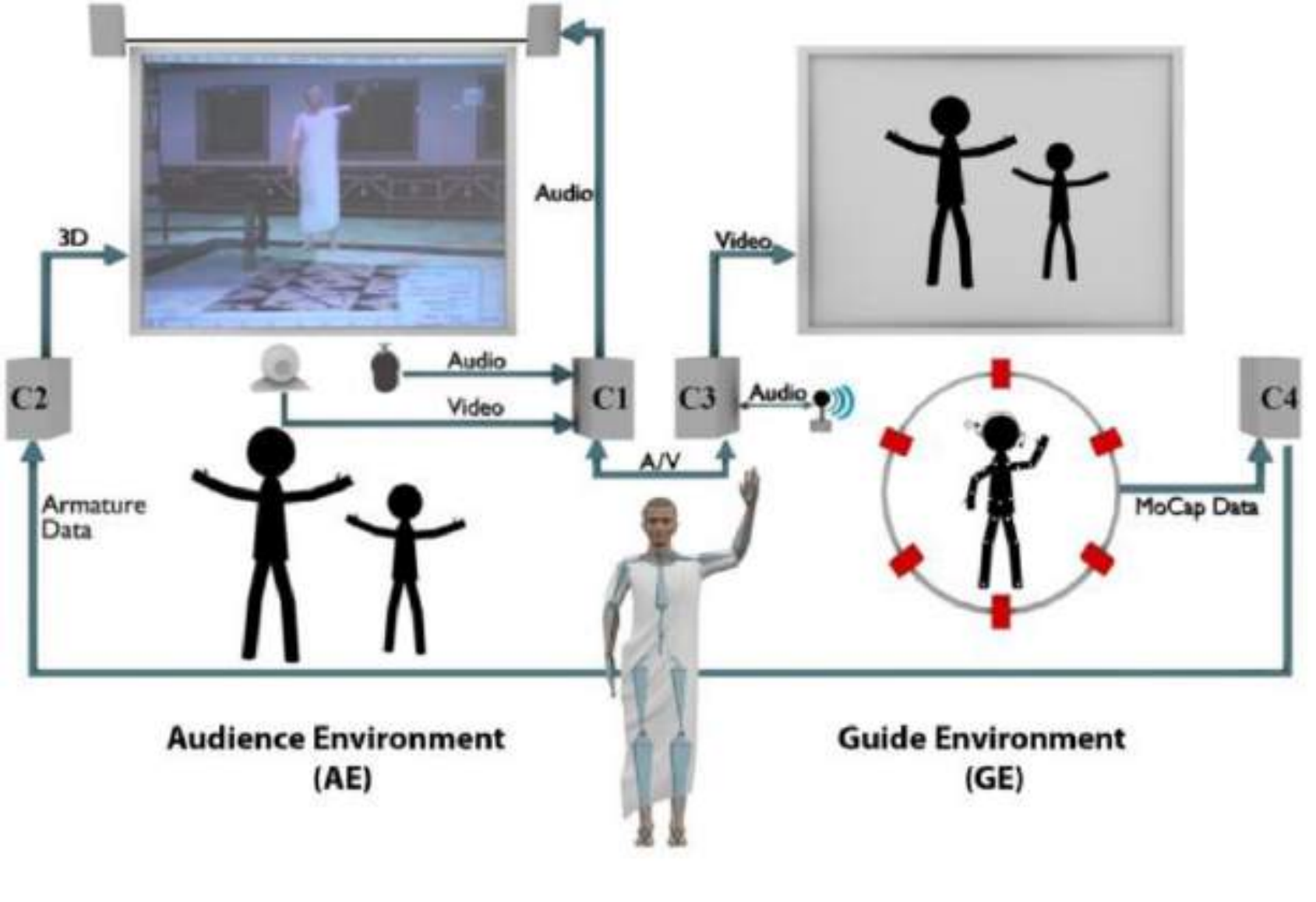
Release object

VE's evolution - results

158 Popovici, D. M., Bogdan, C. M., Polceanu, M., and Querrec, R. Applying of an ontology based modeling approach to cultural heritage systems. Advances in Electrical and Computer Engineering 11, 3 (2011), 105-110. http://dx.doi.org/10.4316/AECE.2011.

P1 11-041/2007 "Using virtual reality in 3D multimodal reconstruction of historical sites: TOMIS", dir.(2007-2010)

VE's evolution += real time animations



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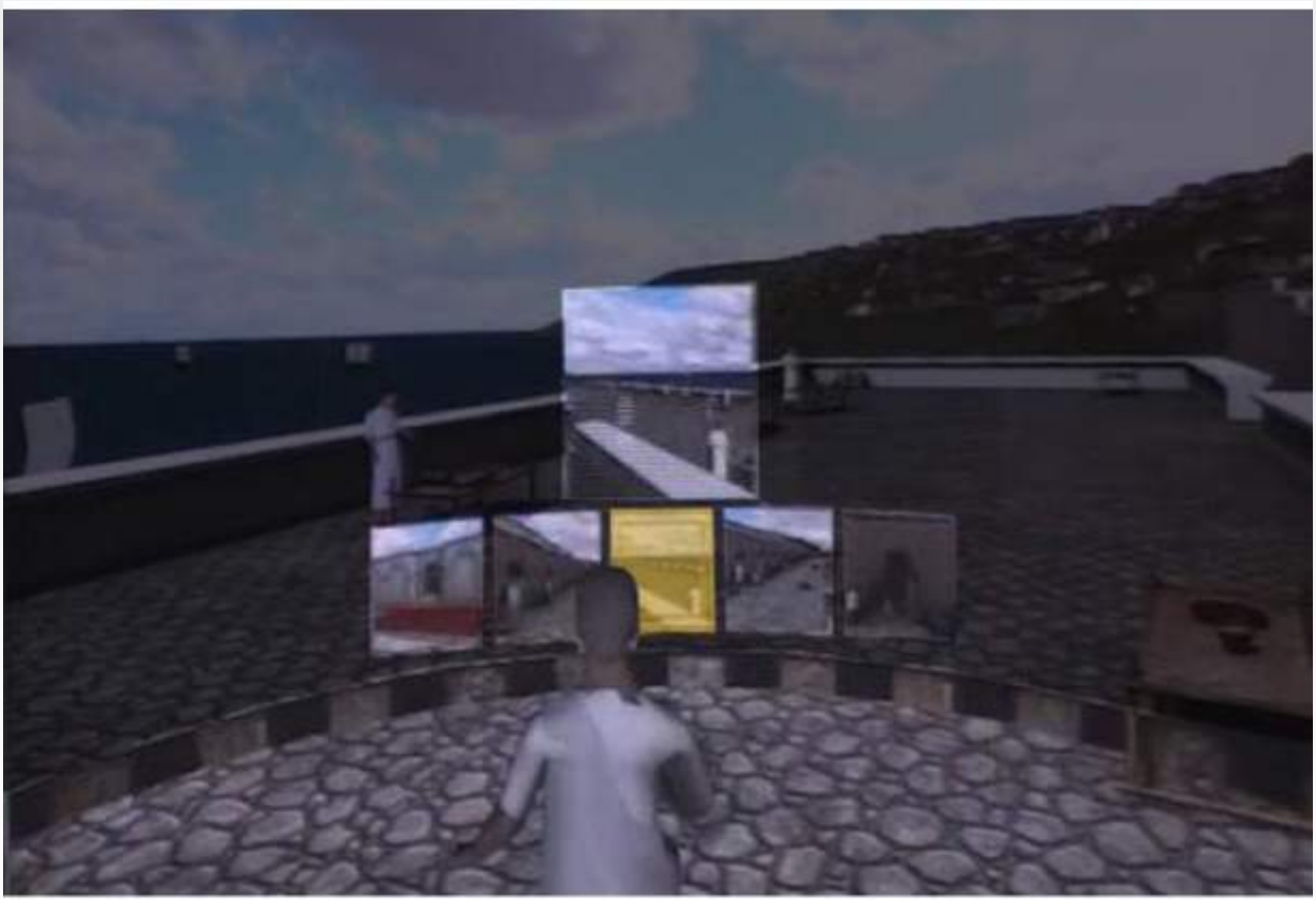


VE's evolution - results

192 Rizea, A. V., Dincă, A. F., Ilie, C., Hramco, V., Polceanu, M., and Popovici, D. M. Utilizarea tehnologiei motion-capture în medii interactive în timp real. In Proc. of RoCHI2011 (2011), pp. 119-122.

- Rizea V., *Behavioral modeling system based on motion capture*, Master thesis, Ovidius University of Constanta, Romania, 2012. Coord. Popovici, D.M.

Behavioral view on VE - first steps forward

Designing and developing of an adaptive behavioral model of virtual societies based on multiagent systems

- Research will be dedicated towards developing agents that reason and behave based on ontology mechanisms which will provide semantic information to actions performed within the virtual environment.

Applications:

- Once basic animations have been registered by an evolutive agent, and semantic meaning has been added to them, the agent will eventually, through semantics, be able to develop new behaviors by combining the said animations.

Behavioral view on VE - and one more

Exploring the potential of both objects and activities awareness, in the context of user social experience

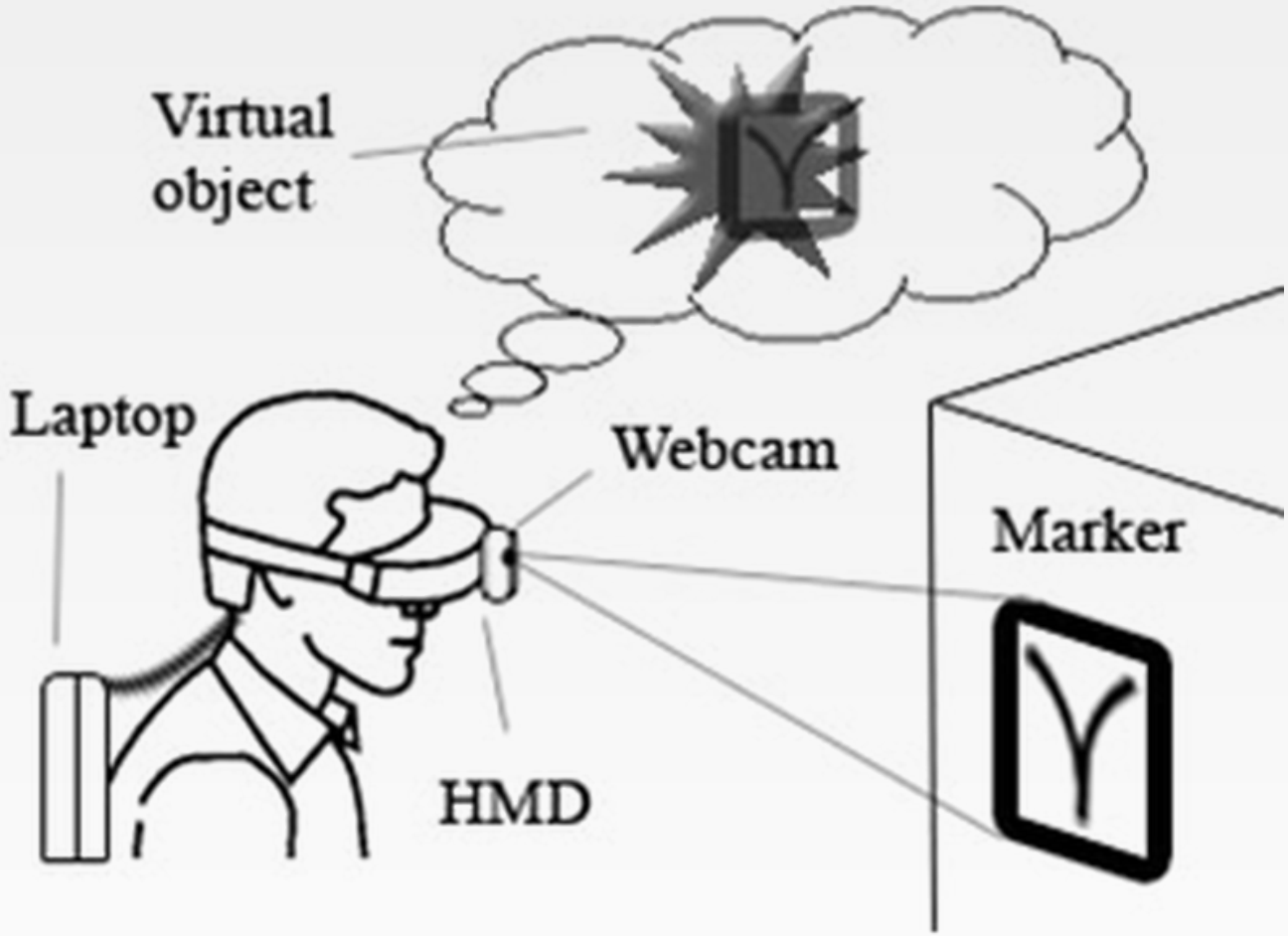
- We focus on the ways in which the specific behavior of the virtual society can be modeled in order to transform the passive viewers into active participants.
- Reversely, explicit user interaction can affect the behavior of the virtual society which now has to take into account a new type of input - that of a new participant in cultural immersion.

Model for virtual environment

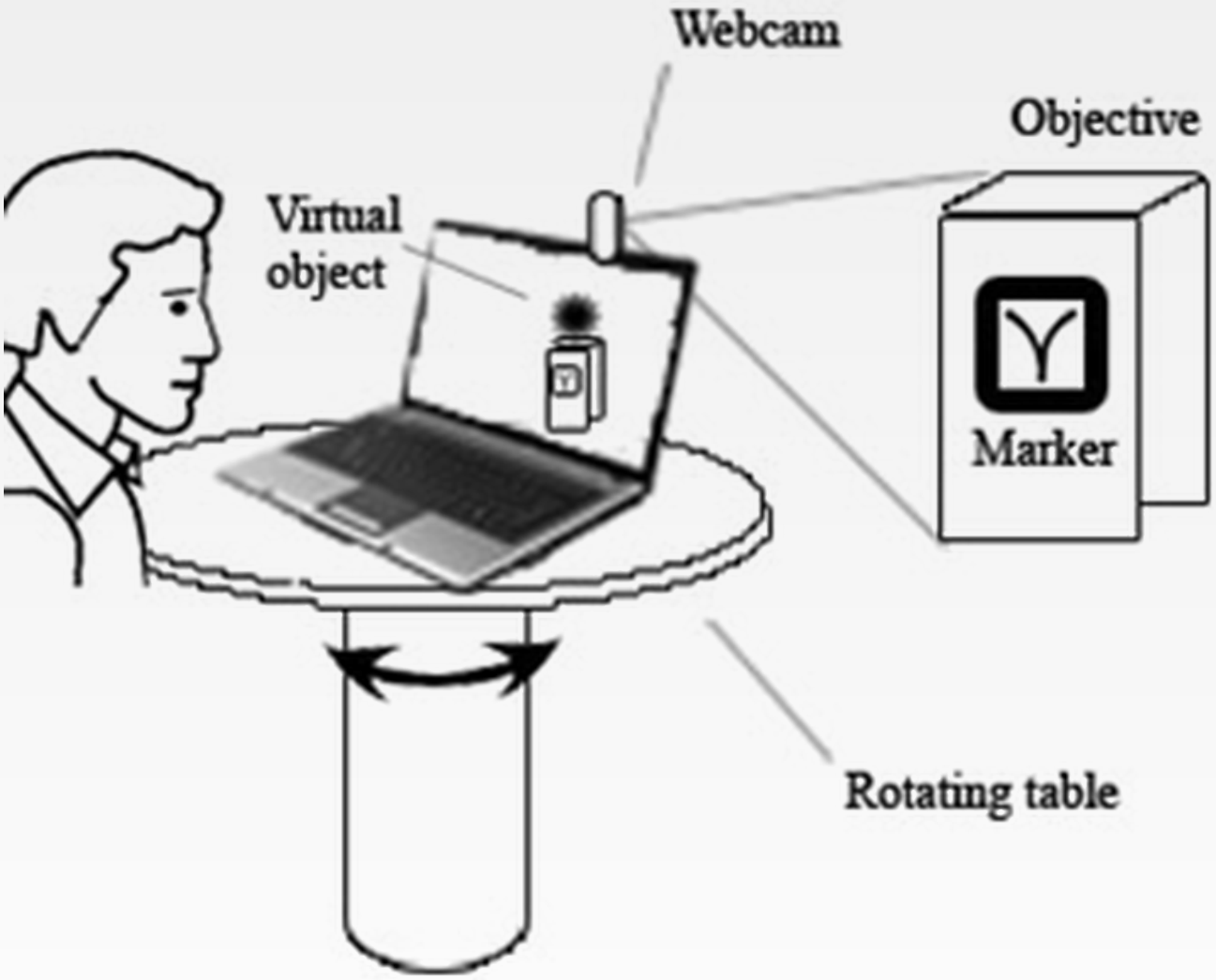
Interactional view

Goal: Let the user to behave naturally while experimenting virtual environments

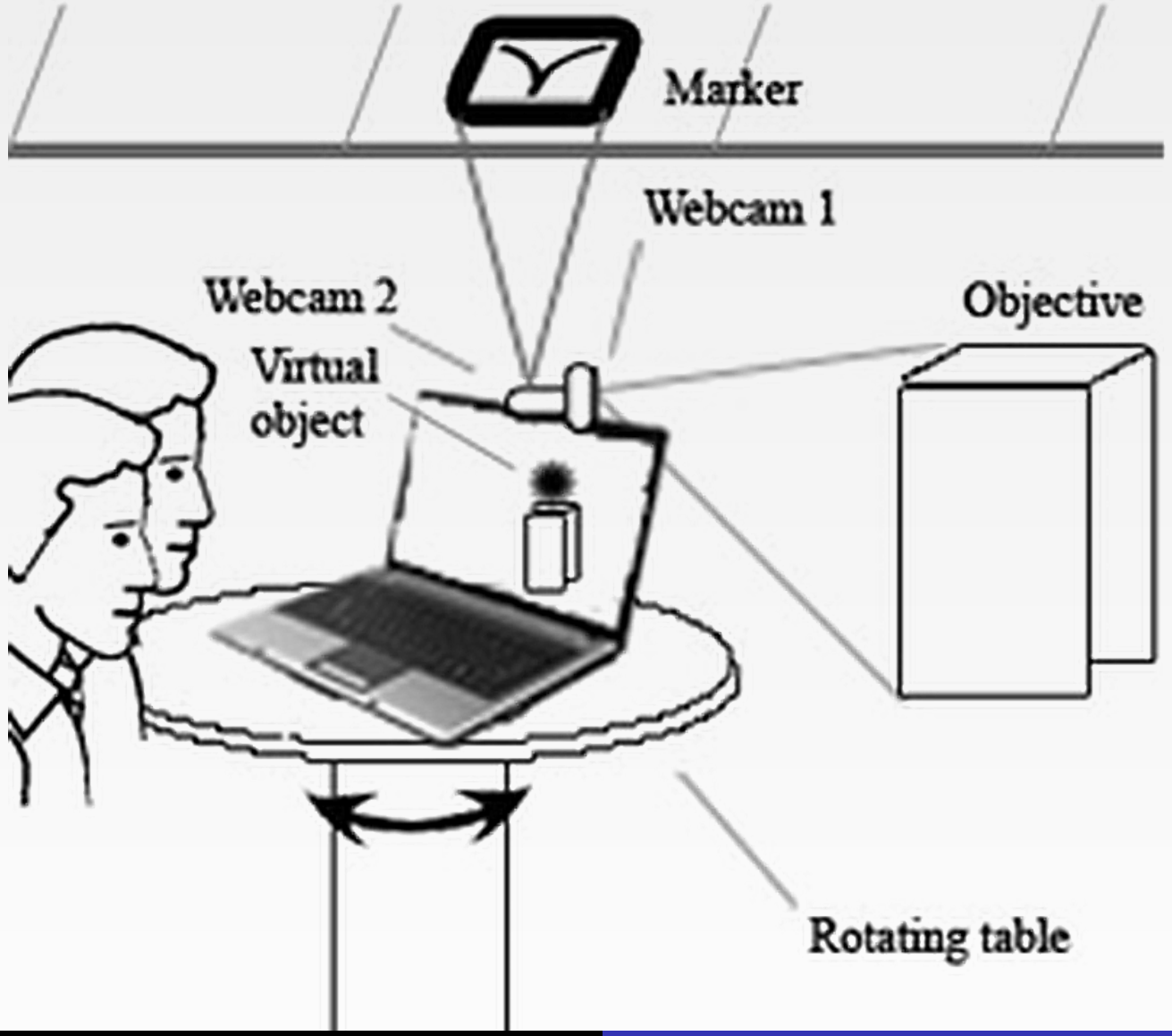
Exploring VE = navigation



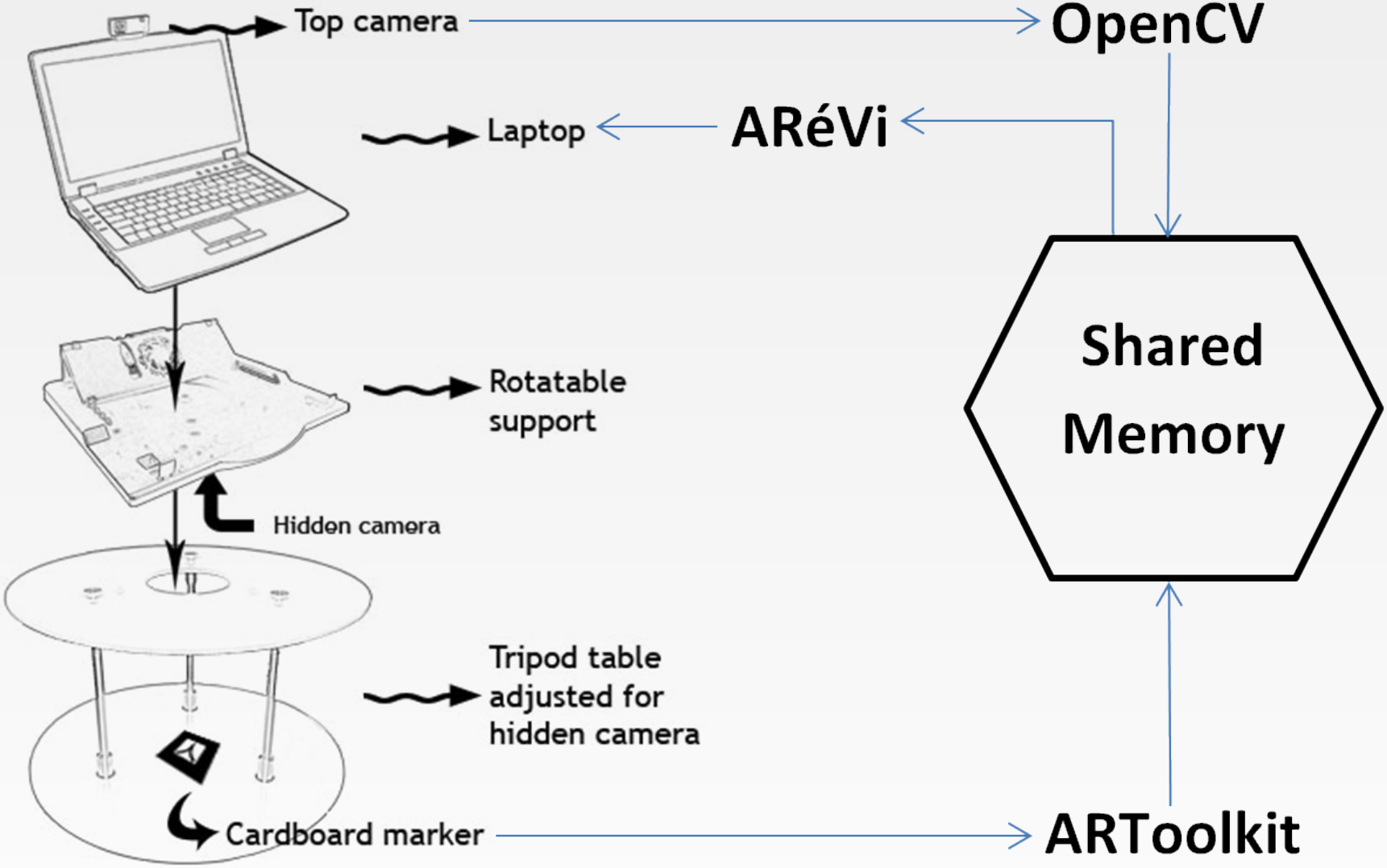
Exploring VE = navigation



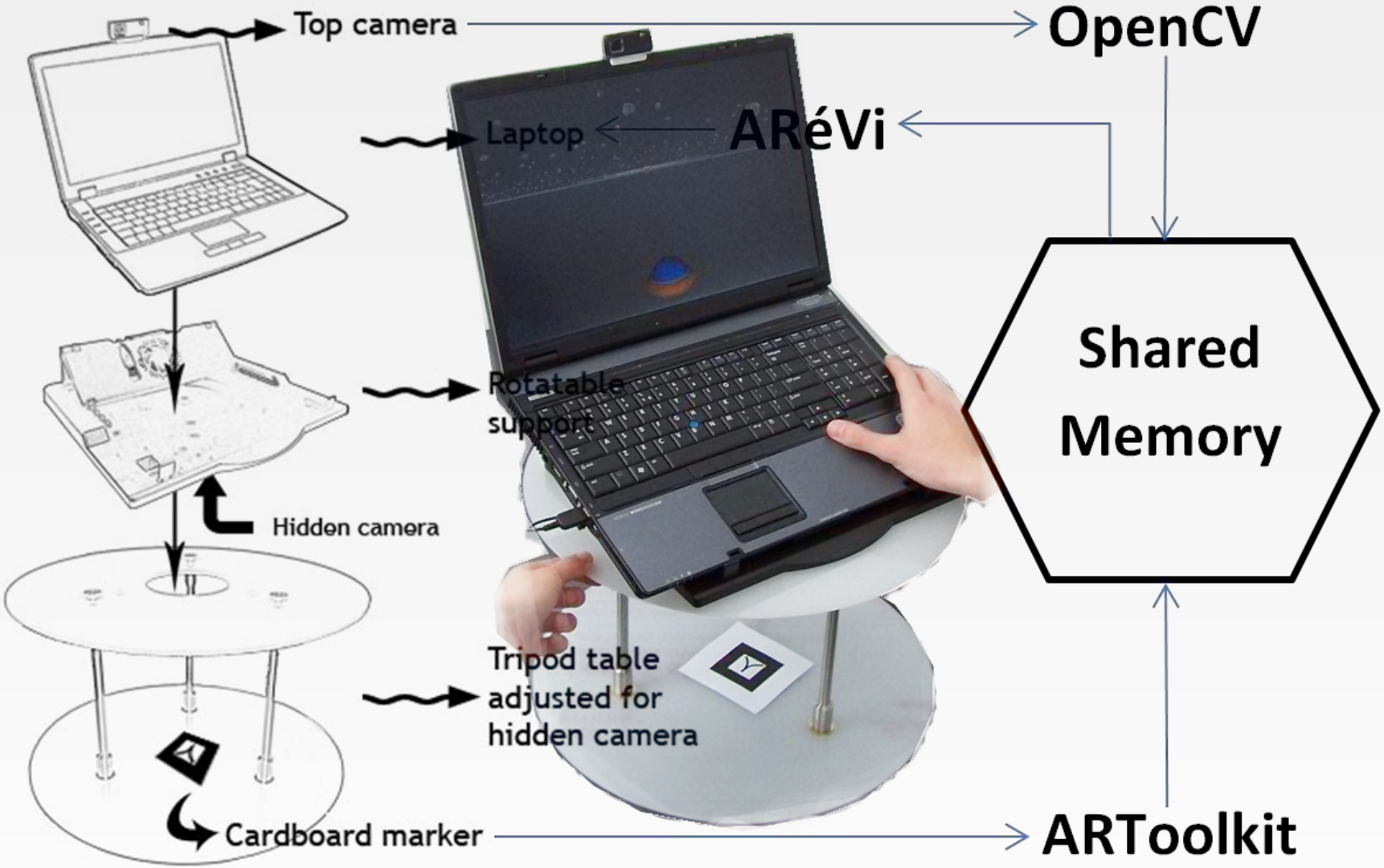
Exploring VE = navigation



Exploring VE = navigation



Exploring VE = navigation



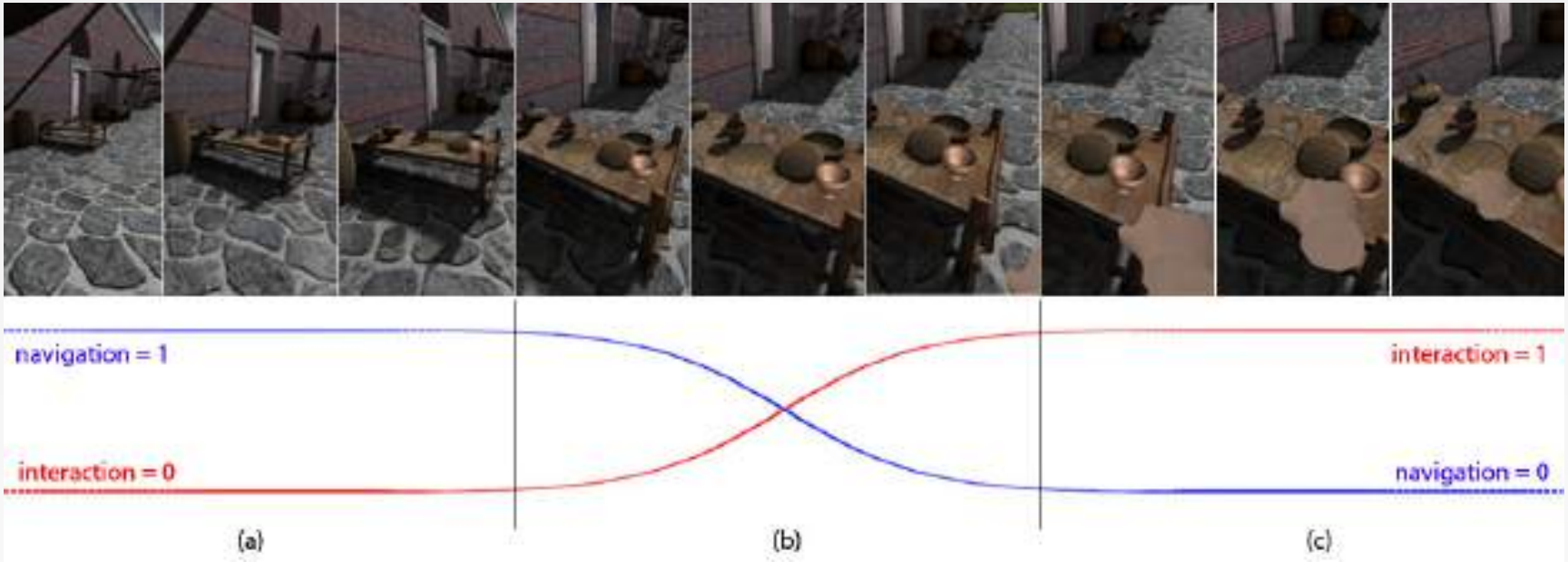
Exploring VE = navigation - results

166 Popovici, D. M., and Polceanu, M. *Interactive informative unit based on augmented reality technology*. In Proceedings of ICVL2008, Bucharest Univ. Press, pp. 307-316. WOS:000289381800031.

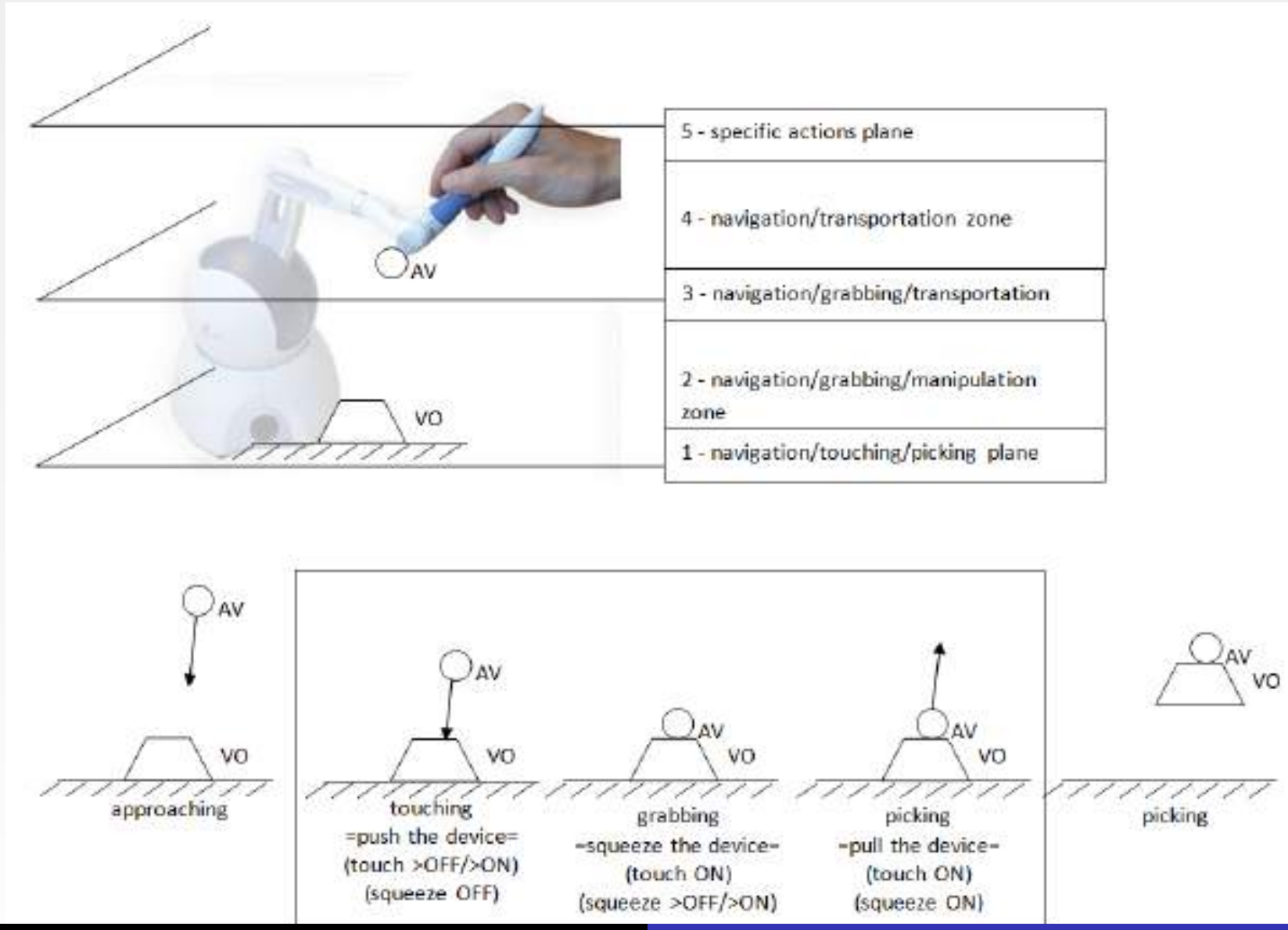
Exploring VE = navigation - results

151 Polceanu, M., Popovici, A., and Popovici, D. M. *A system for panoramic navigation inside a 3D environment*. In 18th International Conference on Computer Graphics, Visualization and Computer Vision'2010 , pp. 213-219.

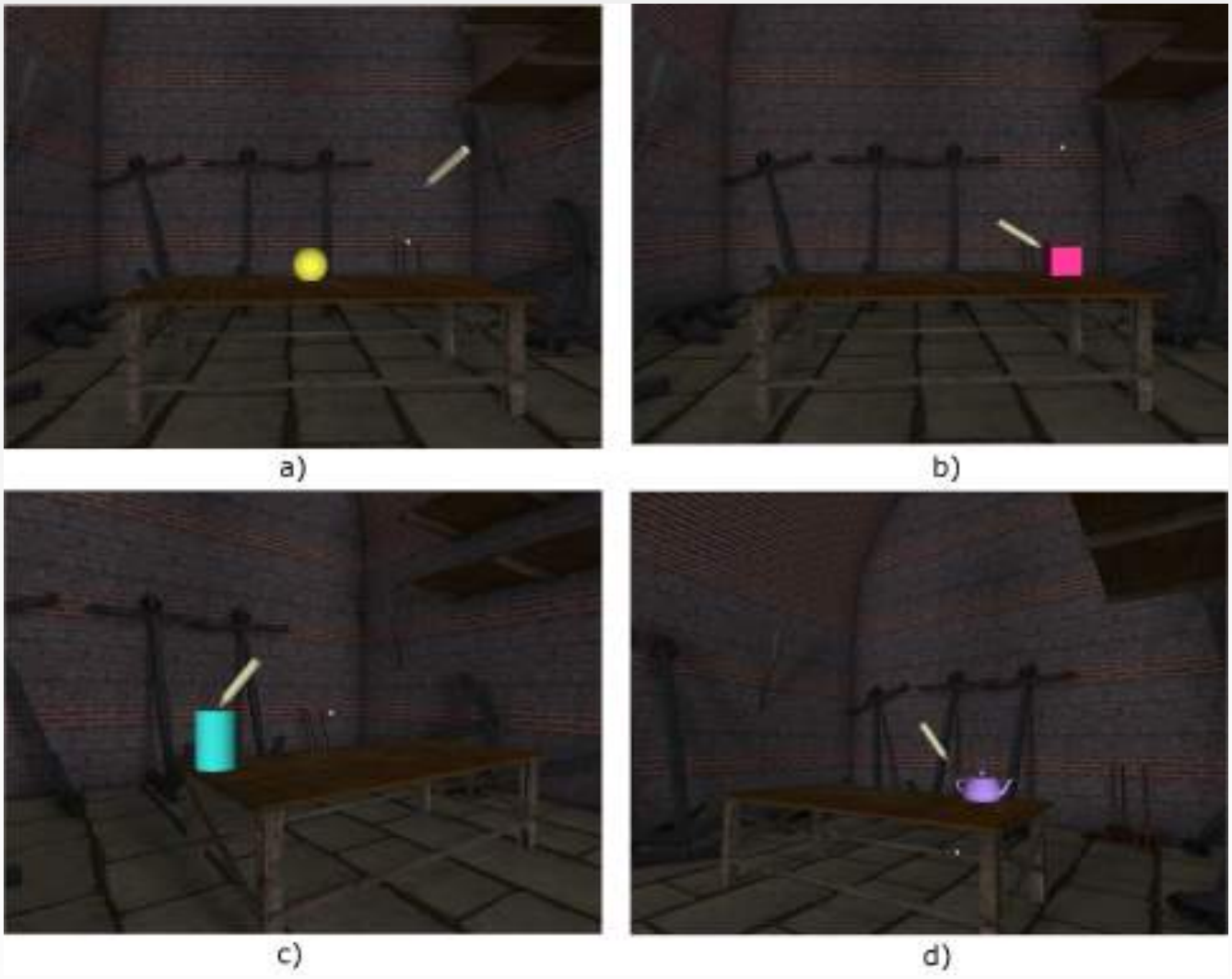
Exploring VE : from navigation to interaction



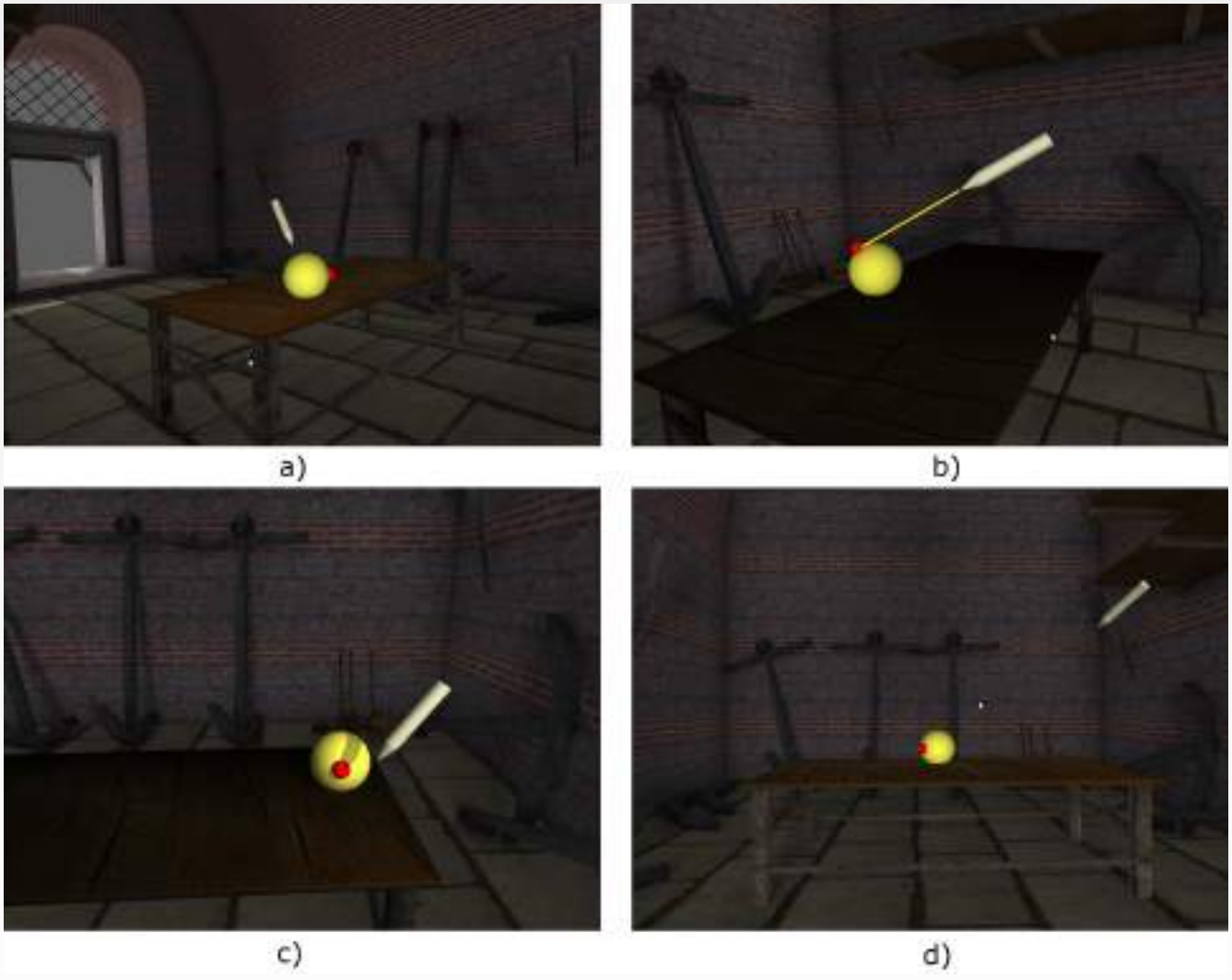
Exploring VE : from navigation to interaction



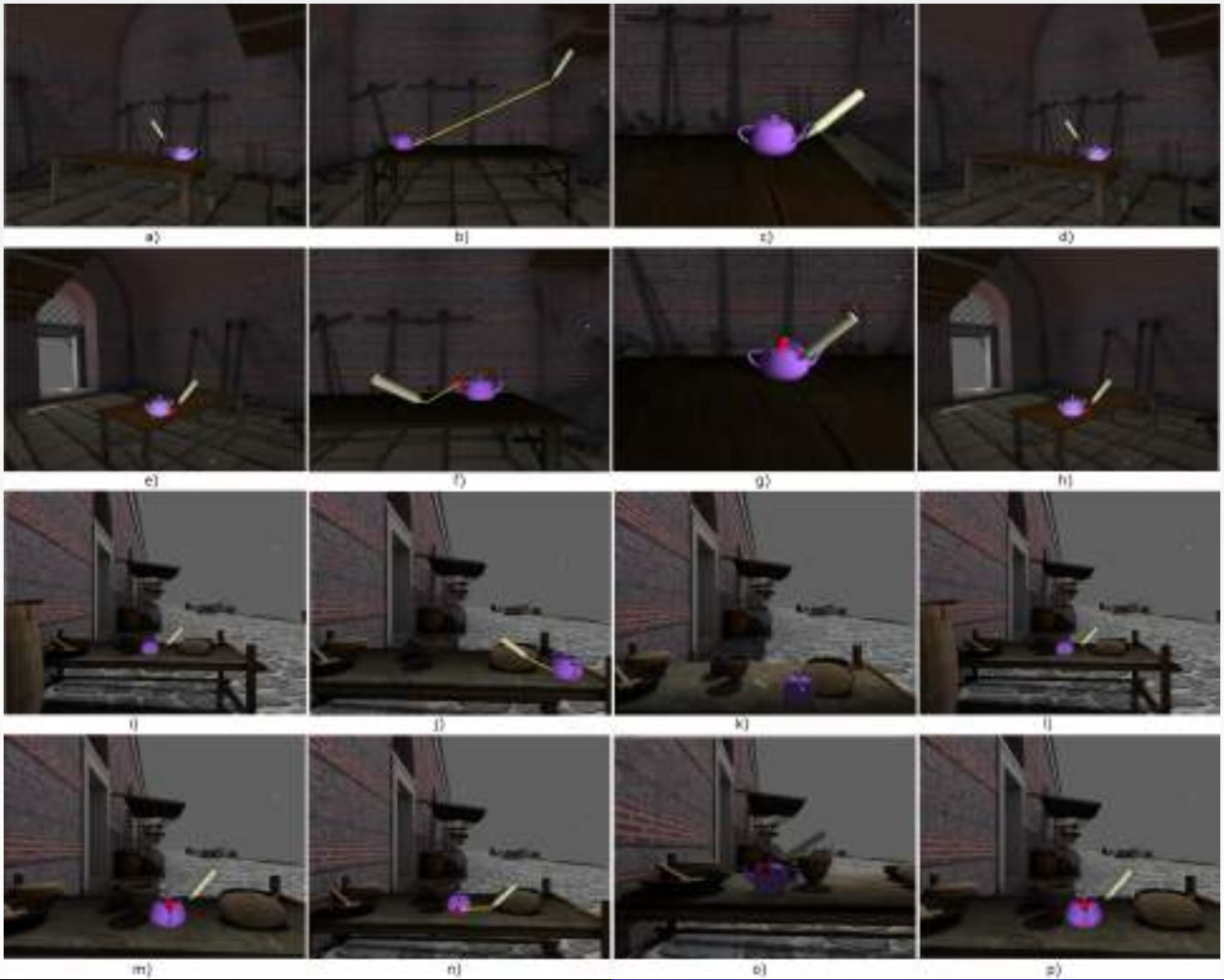
Exploring VE += reaching and touching objects : object complexity



Exploring VE += reaching and touching objects : assistance method



Exploring VE += reaching and touching objects : task complexity & object topology



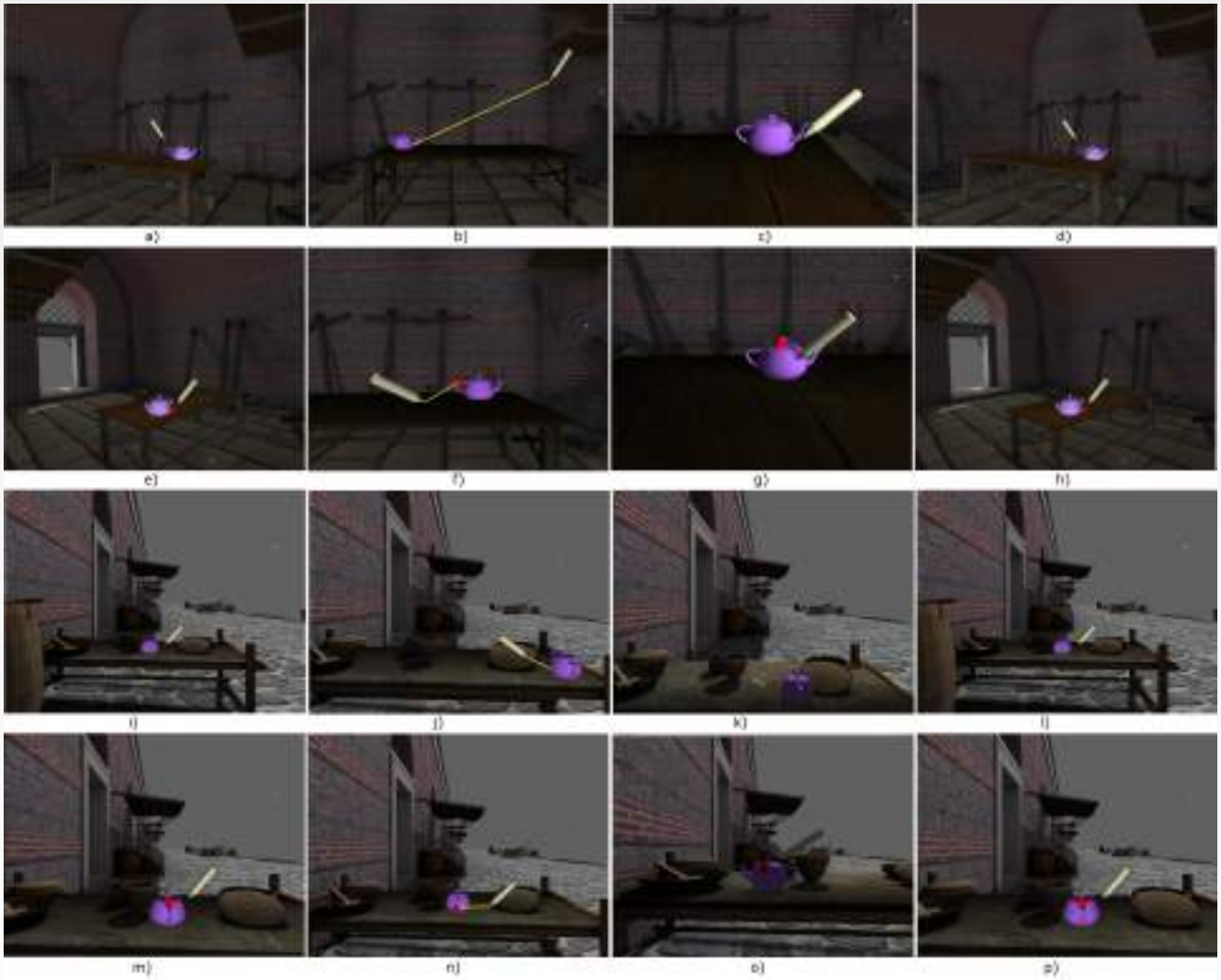
Exploring VE - reaching and touching objects - results

167 Popovici, D. M., Polceanu, M., and Popescu, A. *Augmenting user experience in virtual environments through haptic feedback*. In Proceedings of the 7th Balkan Conference on Informatics Conference (New York, NY, USA, 2015), BCI '15, ACM, pp. 10:1-10:6.

P1 11-041/2007 "Using virtual reality in 3D multimodal reconstruction of historical sites: TOMIS"

- Popescu, A. *Tehnici de asistenţă haptică într-un mediu virtual*, Bachelor Thesis, Ovidius University of Constanta, 2012, Coord. Popovici, D.M.

Exploring VE - reaching and touching objects - results



Exploring VE - reaching and touching objects - results

26 Bogdan,C.M., Dincă,A.F., Popovici,D.M. *A brief survey of visuo-haptic simulators for dental procedures training*. In Proc of ICVL 2011, pp. 54-60. WOS:000323685900005.

30 Bogdan,C.M., Popovici,D.M. *Information system analysis of an elearning system used for dental restorations simulation*. Computer methods and programs in biomedicine 107, 3 (2012), 357-366.

164 Popovici, D. M., Hamza-Lup, F., and Bogdan, C. *Haptic feedback systems in education*. In Conference Proceedings of eLearning and Software for Education (eLSE) (2013), pp. 509-514. WOS:000328097500082.

165 Popovici, D. M., Hamza-Lup, F., Şeitan, A., and Bogdan, C. *Comparative study of apis and frameworks for haptic application development*. In 12th International Conference on Cyberworlds (Darmstadt, Germany, 2012), IEEE, pp. 37-44. ISBN: 978-0-7695-4814-2/12.

P9 12-083/2008 ”Virtual and augmented realtity technologies in the simulation of teeth preparation for fixed prothesys : VIRDENT” - technical manager / IT specialist (2008-2012)

- Dincă, A.F. *Haptic assistance in skills training. VirDenT prototype*, Master thesis, Ovidius University of Constanta, 2012, Coord. Popovici, D.M.

Exploring VE - reaching and touching objects - results

Exploring VE - reaching and touching objects - results

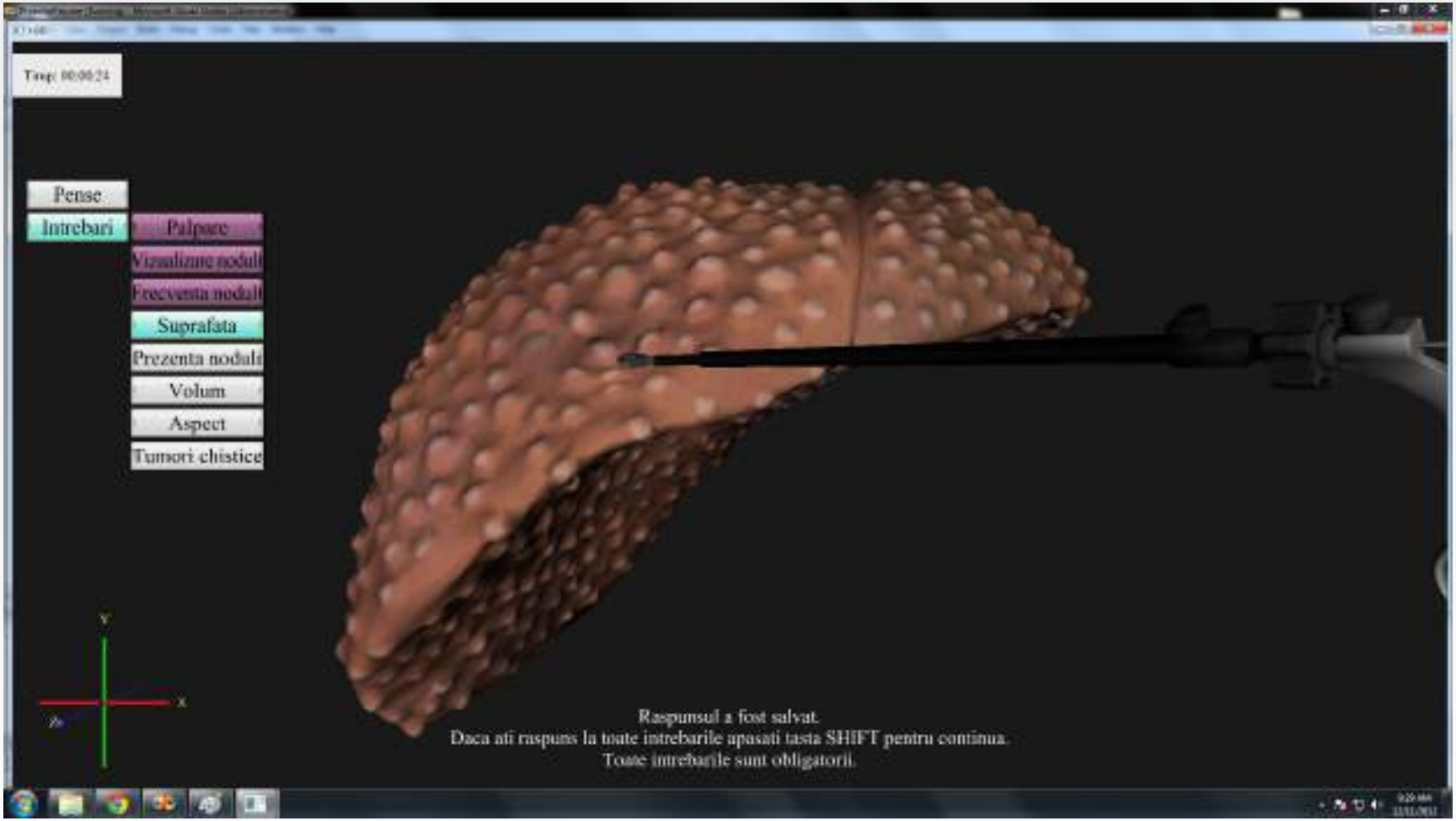
83 Hamza-Lup,F., Şeitan,A., Petre,C., Polceanu,M., Bogdan,C., Nicola,A., Popovici,D.M. *Haptic user interfaces and practice-based learning for minimally invasive surgical training*. In Proc of ICVL 2011 (2011), pp. 45-53. WOS:000323685900004.

84 Hamza-Lup,F., Şeitan,A., Popovici,D.M., Bogdan,C. *Liver pathology simulation: Algorithm for haptic rendering and force maps for palpation assessment*. In MMVR 2013, pp. 175-181.

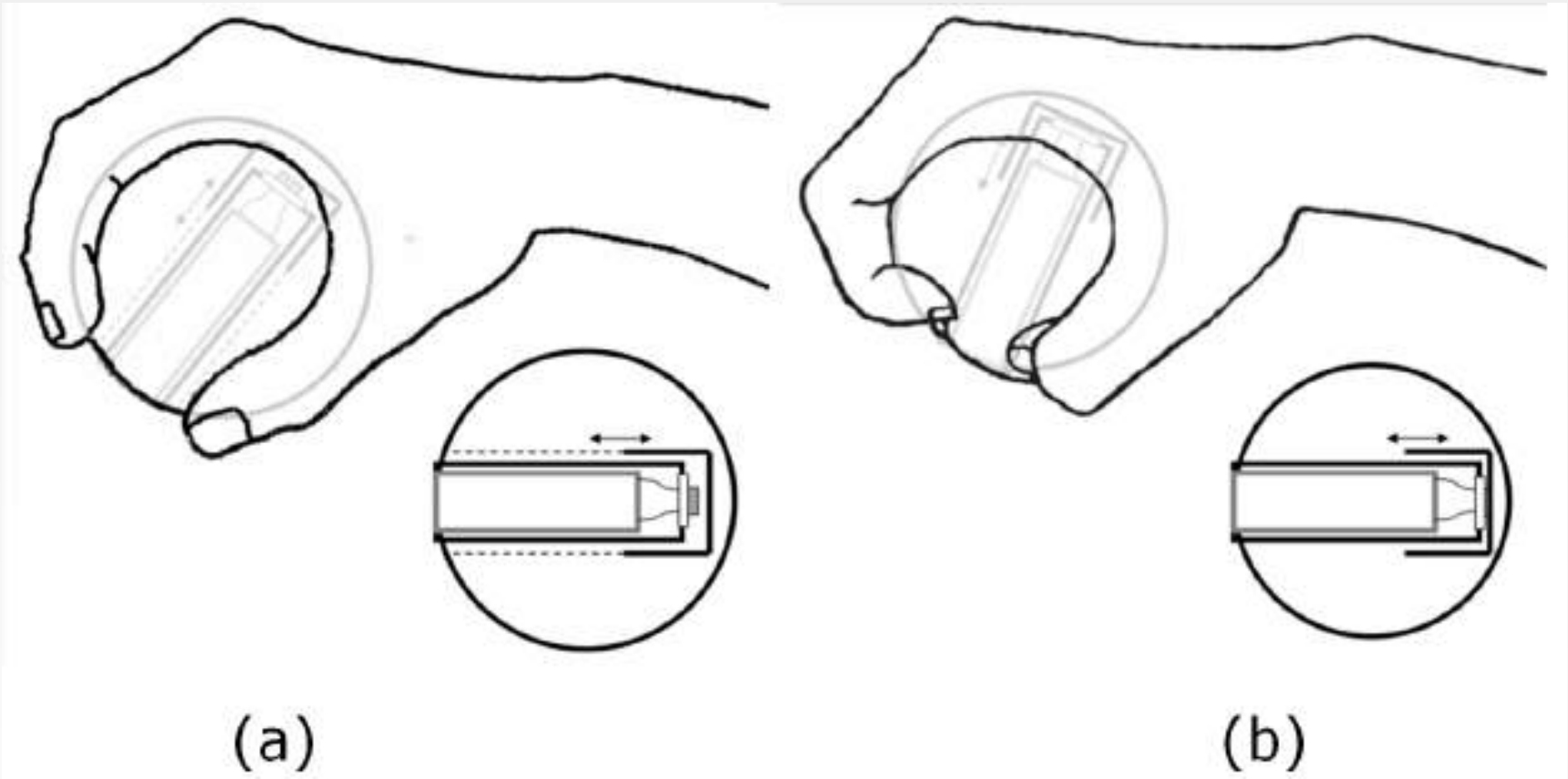
P2 HapticMed - Haptic interfaces in medical applications - POSCCE contract no. 128/2.06.2010, cod SMIS 12277, no. online 567, O.2.1.2, executive director, (2010-2013)

- Şeitan, A. *Simularea haptică a gestului chirurgical de palpare a ficatului*, Bachelor Thesis, Ovidius University of Constanta, 2012, Coord. Popovici, D.M.
- Corleancă, C.A. *Medii virtuale pentru formare profesională. Testare şi evaluare în procedura medicală de palpare*, Bachelor Thesis, Ovidius University of Constanta, 2013, Coord. Popovici, D.M.

Exploring VE - reaching and touching objects - results



Exploring VE + grasping objects = Experimenting VE



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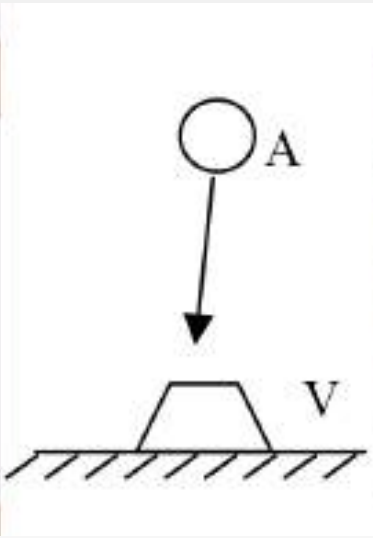

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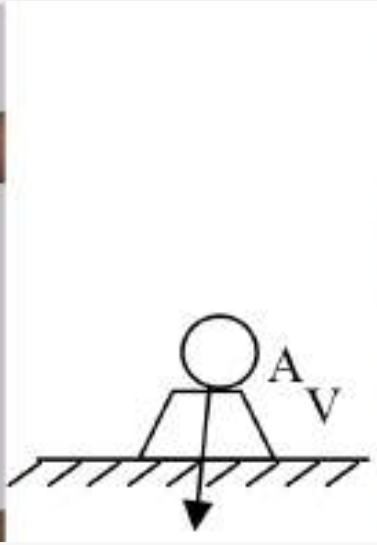

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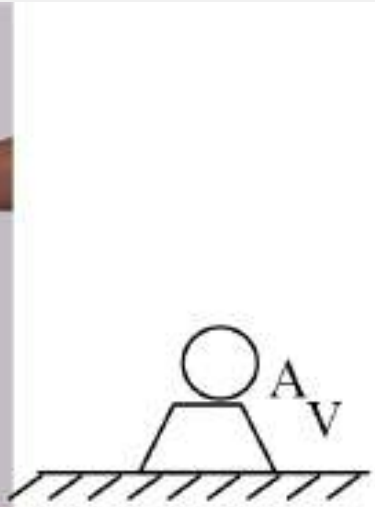

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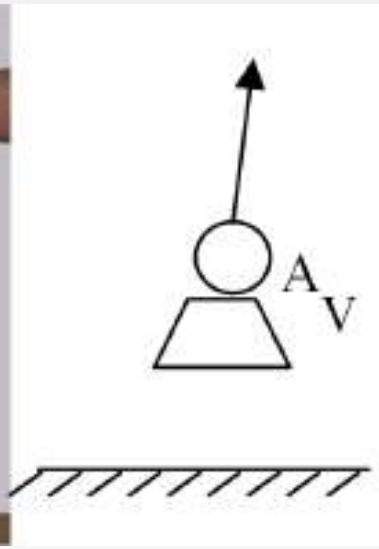
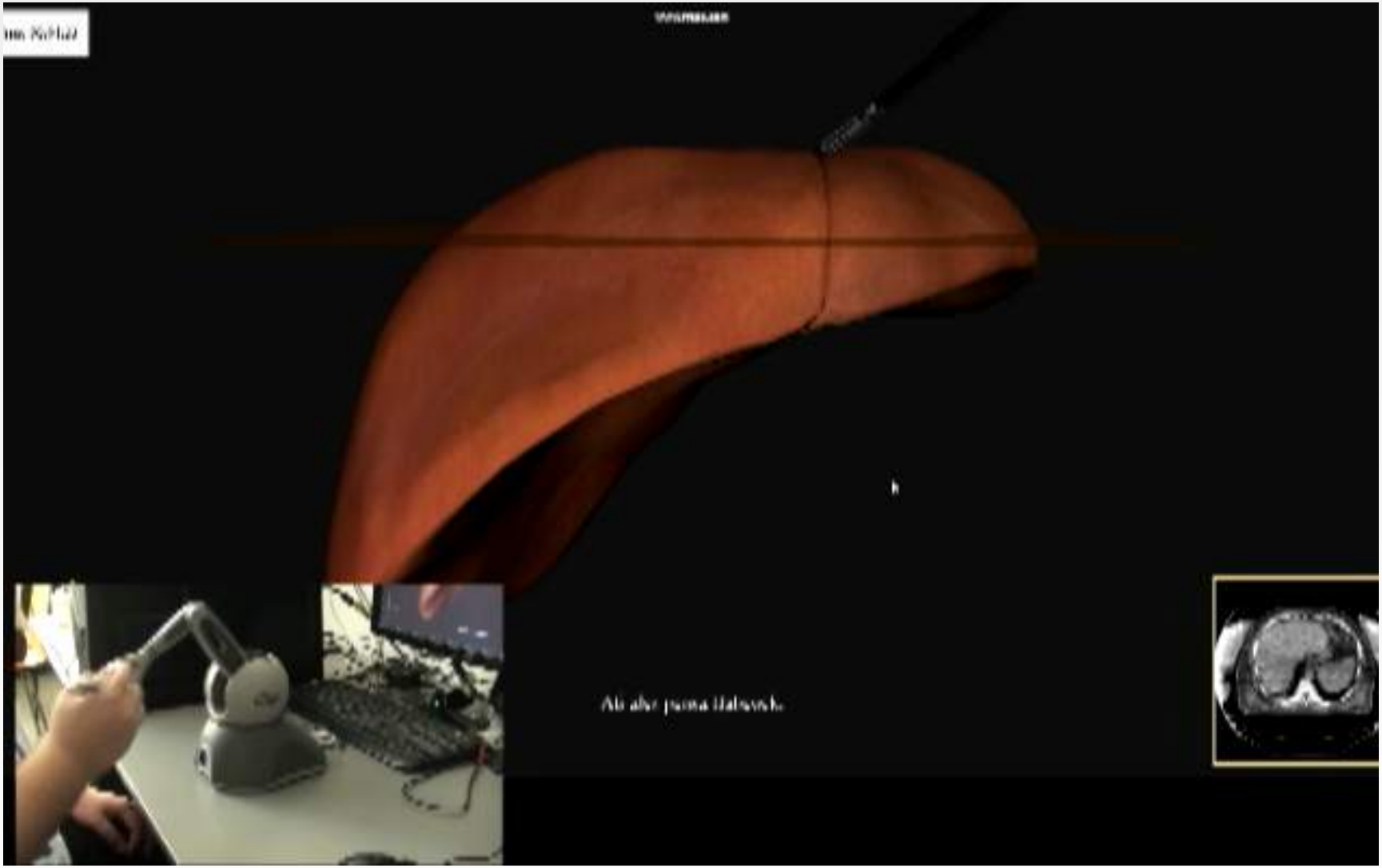


Experimenting VE - results

182 Popovici, D. M., Vătavu, R., and Polceanu, M. *GRASPhere: A prototype to augment indirect touch with grasping gestures*. In Proceedings of the 14th International Conference on Mobile and Ubiquitous Multimedia (New York, NY, USA, 2015), MUM'15, ACM, pp. 350-354.

Experimenting VE - results

Experimenting VE - results



Interactional view on VE - some steps forward

Designing, development, and experimentation of natural interaction metaphors dedicated to cultural immersion

- The goal is to transform the user in a participative actor into a specific task together with members of the virtual society.

Investigations on wearable computing together with tangible interfaces by augmenting them with emotion detection.

- How interactions can occur seamlessly, intuitively, and fluently, while switching from one device to another, from one metaphor to another, or from one context to another, by combining existing modalities or, better, invent new ones.

Interactional view on VE - one more step forward

Evaluation of current haptic-oriented devices for application scenarios

- Understanding the added effect of grasping for indirect touch, together with the potential of virtual object and social affordance the user may detect in collective experiences.

Research activities

Main results

Research projects

- 5 international projects [P9, P10, P12, P13, P14][1]
- 5 national projects [P2, P4, P7, P8, P11]
- 2 individual mobilities [P5, P15]

- educational, training and heritage dissemination virtual environments

[1] All these projects are indexed as their appear in my CV.

Educational Virtual Environments

Educational Virtual Environments

- P14: EVE - Environnements Virtuels pour Enfants
- P13: REVE - Renforcement EVE - Environnements Virtuels pour Enfants
- *distribution, interaction, communication*
- P4: EMULACTION - Environnement Multimodal pour Activites Cooperatives Transnationales de formation

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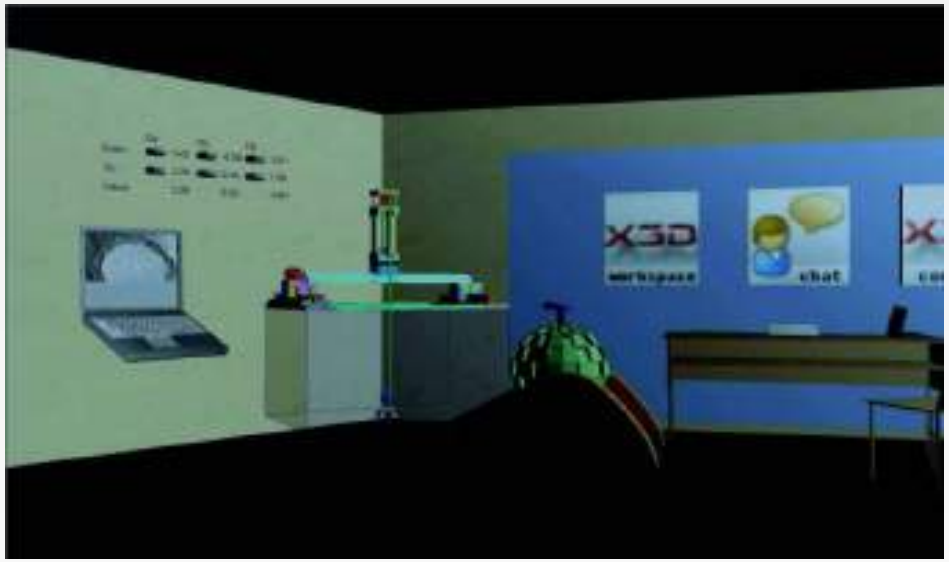


Virtual heritage virtual environments

Virtual heritage virtual environments -VENUS - Phare CBC

- P10: Venus at Lower Danube

Virtual heritage virtual environments -TOMIS - PN II

- P8: Using virtual reality in 3D multimodal reconstruction of historical sites

Training virtual environments

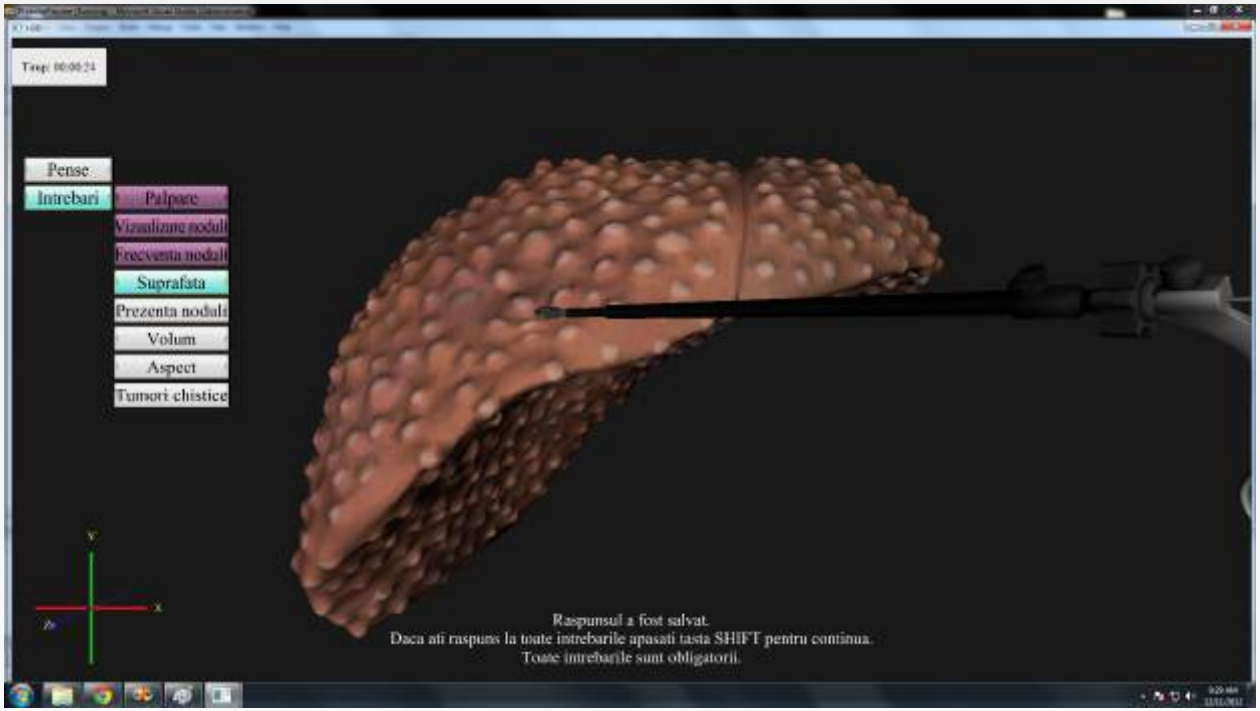
Training virtual environments - VIRDENT - PN II

- P7: Virtual and augmented realtity technologies in the simulation of teeth preparation for fixed prothesys

- *haptic interaction, plastic deformation, uniform body consistency*

Training virtual environments - HapticMed - POSCCE

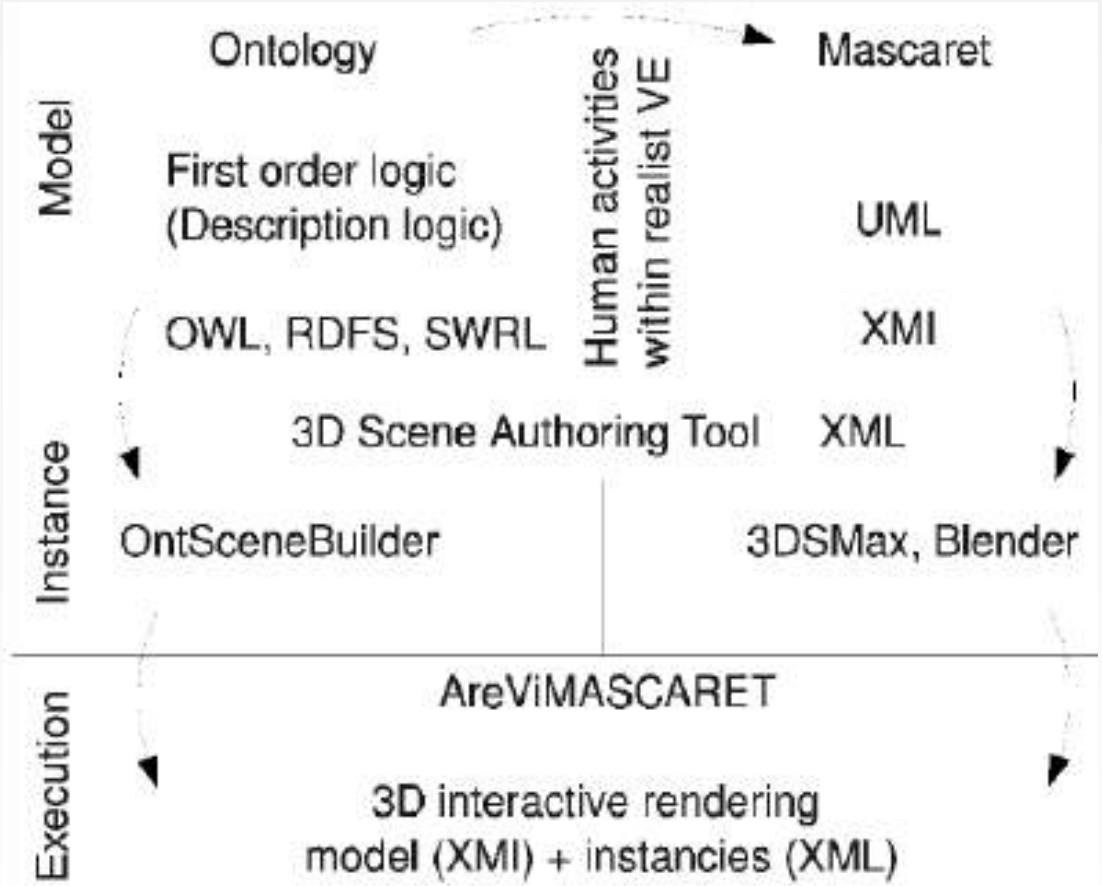
- P4: Haptic interfaces in medical applications



- *haptic interaction, elastic deformation, non-uniform body consistency*

Individual grant

- P5: Individual research grant AUF: PROMETEU - Prototypage d'environnements virtuels informee pour la museologie



Relevant results

- more than 50 research papers
  - 22 ISI papers,
  - 20 BDI papers,
- 3 books and 5 book chapters

More than 80 citations (36 ISI citations and 46 BDI citations)

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More than 80 citations (36 ISI citations and 46 BDI citations)

Future work (II)

- Informational link of different VEs (eventually via IOT)
- Designing and developing of an adaptive, evolutive and emotionally responsive artificial intelligence system that let the user to interact with multimodal representation of VE
- Designing and developing of an adaptive and credible behavioral model of virtual societies based on multiagent systems (agent actions anticipation and validation on semantic basis)

Future work (II) - cont

- Exploring the potential of both objects and activities awareness, in the context of user social experience
- Designing, development, and experimentation of natural interaction metaphors dedicated to cultural immersion
- Investigations on wearable computing together with tangible interfaces by augmenting them with emotion detection
- Evaluation of current haptic-oriented devices for application scenarios

Conclusions

My role?

1. Trust
   - Failure v.s. Success
   - Communication
   - Collaboration
2. Discovery throught research
   - Inventing the future
   - Technological progress
3. Creativity
   - Experimentation by synergy

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Thank you, ALL!

Questions time ...