Trends in Epigenetic Robotics: Atlas 2006

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The first Epigenetic Robotics workshop was held in Lund (Sweden) in 2001. This was the beginning of a series of annual meetings dedicated to original research combining developmental sciences and robotics. Year after year, during the following workshops in Edinburg (UK), Boston (USA), Genoa (Italy) and Nara (Japan), an interdisciplinary community shaped itself[1]. Several research groups contribute regularly to these annual events. Researchers in computer science and robotics but also from other fields start to make reference to the "epigenetic robotics" approach. This suggests that what started as a simple workshop tends now to be internationally recognized as a new field. However, as often in the case of new interdisciplinary research, the frontiers of this new field are difficult to draw with precision. Instead of trying to come up with yet another "a priori" definition of what "epigenetic robotics" is, we take the opportunity, in this introduction to the sixth edition, to try to draw a map of this community and the kind of research questions it explores based on the papers and posters accepted in 2006.

Figure 1 show different representations of the geographical distribution of authors' affiliation. The international nature of the Epigenetic Robotics community appears clearly. The important number of contributions from outside Europe confirm the attractiveness of the conference : the Paris meeting not only has contribution from North America and Japan, but also from Australia and Malaysia. Figure 2 compares the geographical distribution between Europe, North America and Asia with the geographical distribution of the last five epigenetic robotics meeting: both diagrams match well.

The match between the geographical distribution of authors in Epirob 2006 and past venues is confirmed by the authors' loyalty to the conference. Figure 3 shows the percentage of papers in the 2006 proceedings in which at least one author has already published in past Epigenetic Robotics workshops. This concerns more than a half of the papers. This balance between new and past contributors is again a good sign of the health of these annual meetings. Authors who contribute to Epigenetic Robotics meetings want to contribute again, but the conference is also sufficiently open to the outside to attract many newcomers.

How interdisciplinary is the research presented at Epigenetic Robotics 2006? Figure 4 shows the percentage of papers and posters in the 2006 proceedings in which at least one author is affiliated to a psychology, neuroscience or linguistic department. This concerns 21 % of the contributions. This does not imply that other papers are not interdisciplinary. An important number of authors that publish in Epigenetic Robotics and who are affiliated to computer science or robotic departments consider that their primary research objective is to contribute to the progress of developmental sciences. Yet, despite an increasing interest from life and human sciences to the research conducted in Epigenetic Robotics, there are only a minority of actual active interdisciplinary projects.

Now that we have a better view of the people contributing to Epigenetic Robotics, we can move to the actual research questions addressed. In order to map the trends of this year's papers, we have designed a set of 18 questions covering most of the research topics and methods characterizing contributions in past years: Does the paper deal with attention, language, vision, motivation, intermodality, synchrony, sensorimotor learning? Is it mainly theoretical? Does it include human robot interactions? The complete list of questions is shown on figure 5 as well as the percentage of positive and negative answers of each of them for both the papers and posters of the 2006 proceedings.

Almost half of the papers and posters deal in some form or another with research on attention. Contributions range from models of visual saccades and active vision system to experiments of human robot interaction. A second major topic is imitation, essentially studied in its early forms. Studies include both purely robotic experiments and experiments involving human subjects. In terms of models, a third of the contributions use neural networks models and the same amount of papers explicitely discuss the issue of building internal representations. There is only a

[1] see introductions to the previous proceedings (Zlatev and Balkenius, 2001, Prince, 2002, Berthouze and Prince, 2003, Berthouze and Metta, 2004, Berthouze and Kaplan, 2005)

small number of purely theoretical papers. More generally, studies about early sensorimotor intelligence outnumber largely studies about higher level form of cognition, like language. It is also worth noticing that only 13 % of the contributions discuss precise psychological experiments.

We used this list of questions in order to map the relationships between the papers published in the 2006 proceedings. We associated a 18-dimensional vector to each of the papers with 1 and 0 depending on the answers to each of 18 questions and we simply used the euclidean distance as a similarity measure to compare the papers with one another. Figure 6 shows the relative distance computed using this method. Small distances reveal similarity in terms of topic or method.

Figure 7 displays the same information mapped in two dimensions using a multi-dimensional scaling method (Cox and Cox, 1994). Different overlapping zones can be traced on this map, they correspond roughly to the main themes and sections of the 2006 conference: active vision, motivation, dynamics, sensorimotor development and interaction studies. As any partition, this one is to a large extent arbitrary. Contributions to Epigenetic Robotics are more relevantly viewed as belonging to a continuous space with regional trends.

This rapid overview gives a coherent image of a field that addresses a hard problem from a large variety of complementary perspectives. Development is a puzzle to solve. Future research in Epigenetic Robotics will have to face the interdisciplinary challenge to make the different pieces fit together.

References

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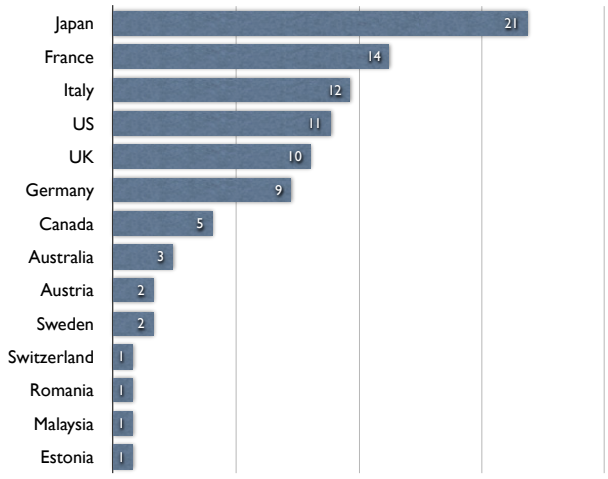

Figure 1: Geographical distribution of authors of papers and posters

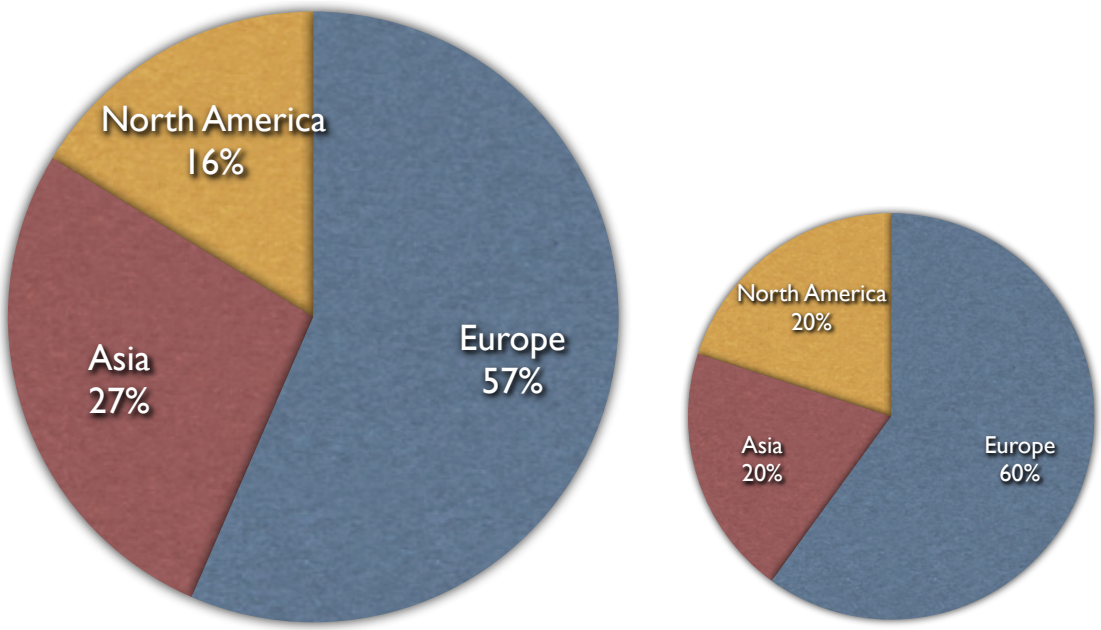

Figure 2: Left:Pie-Chart showing geographical distribution of authors of papers and posters between Europe, North America and Asia. Right: Geographical distribution of last epigenetic robotics meeting

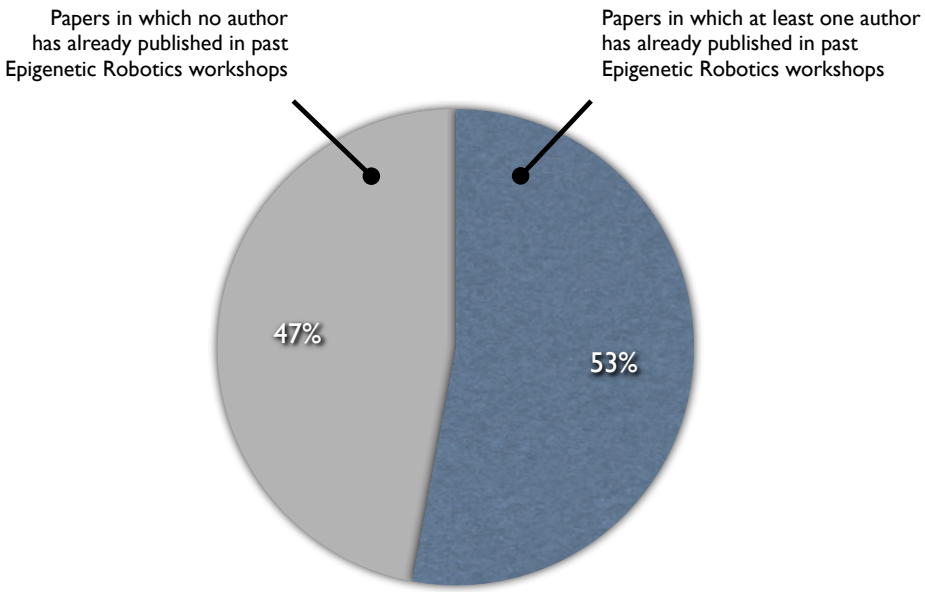

Figure 3: Percentage of papers and posters in the 2006 proceedings in which at least one author has already published in past Epigenetic Robotics workshops

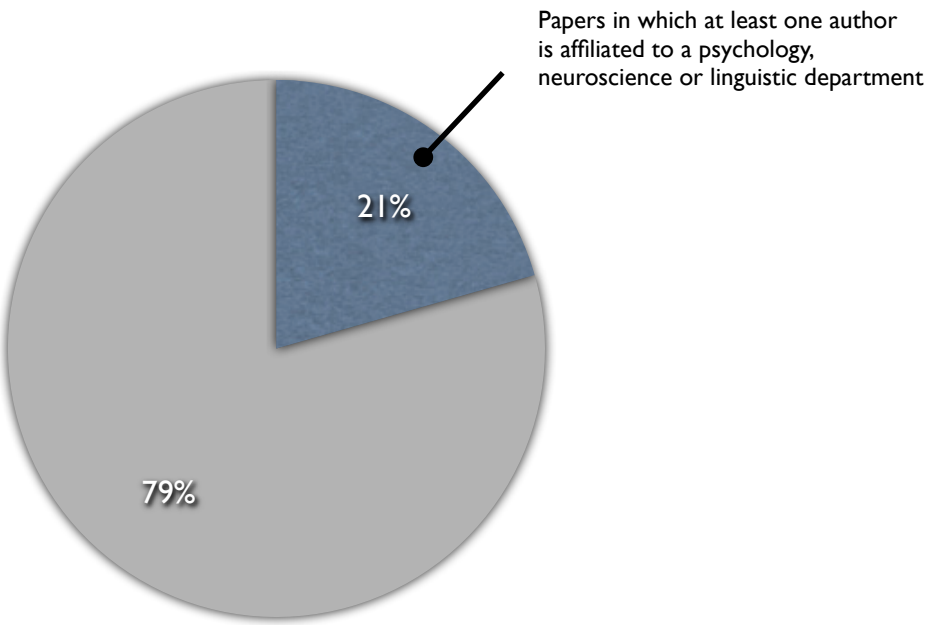

Figure 4: Percentage of papers and posters in the 2006 proceedings in which at least one author is affiliated to a psychology, neuroscience or linguistic department

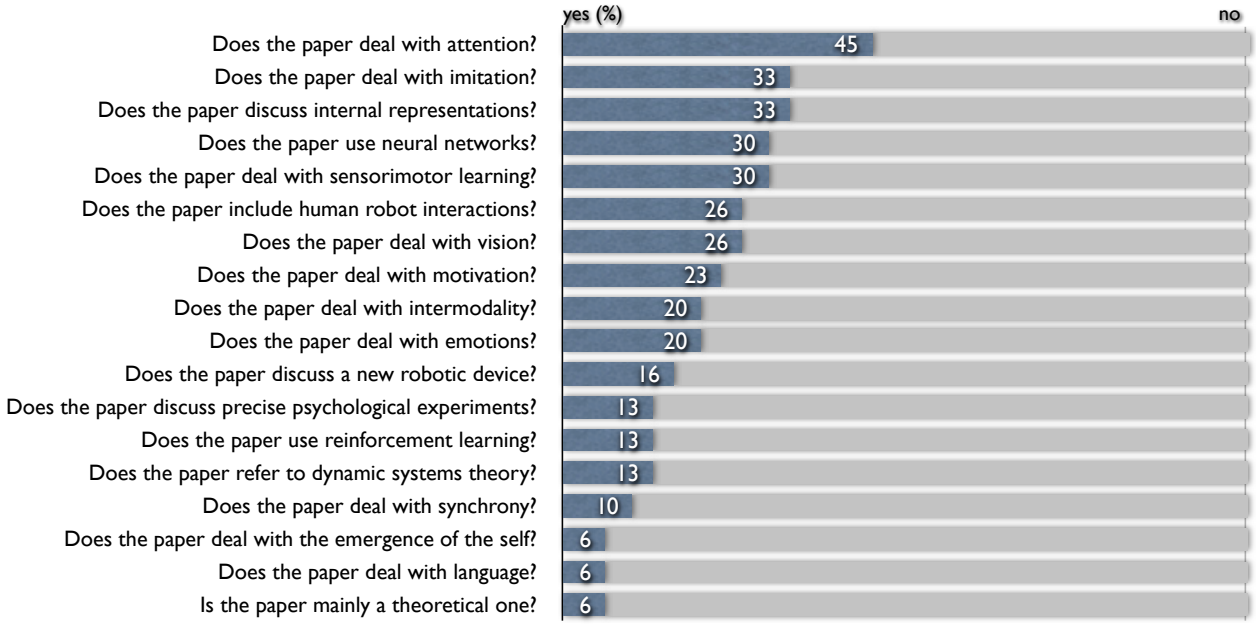

Figure 5: 18 questions to map the trends of the papers and posters of the 2006 proceedings

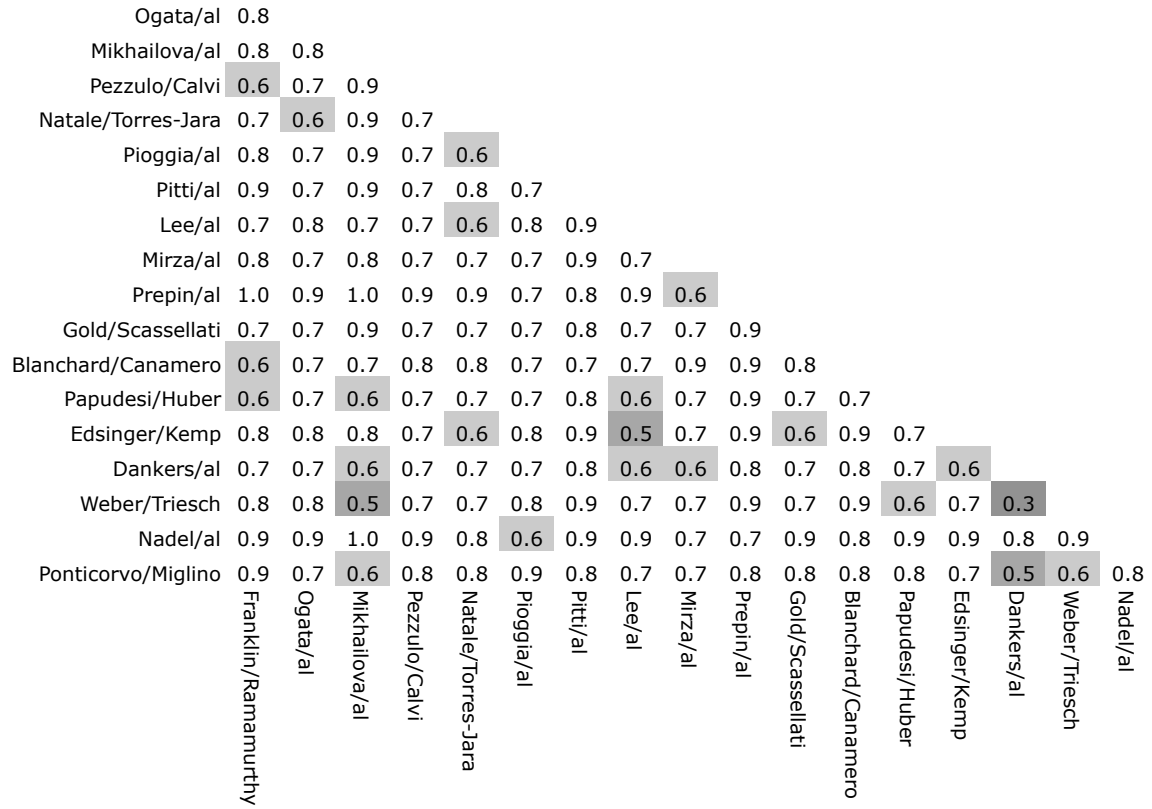

Figure 6: Distance between individual papers based on answers to 18 questions that cover the topics and methods of Epigenetic Robotics. Small distance have been highlighted.

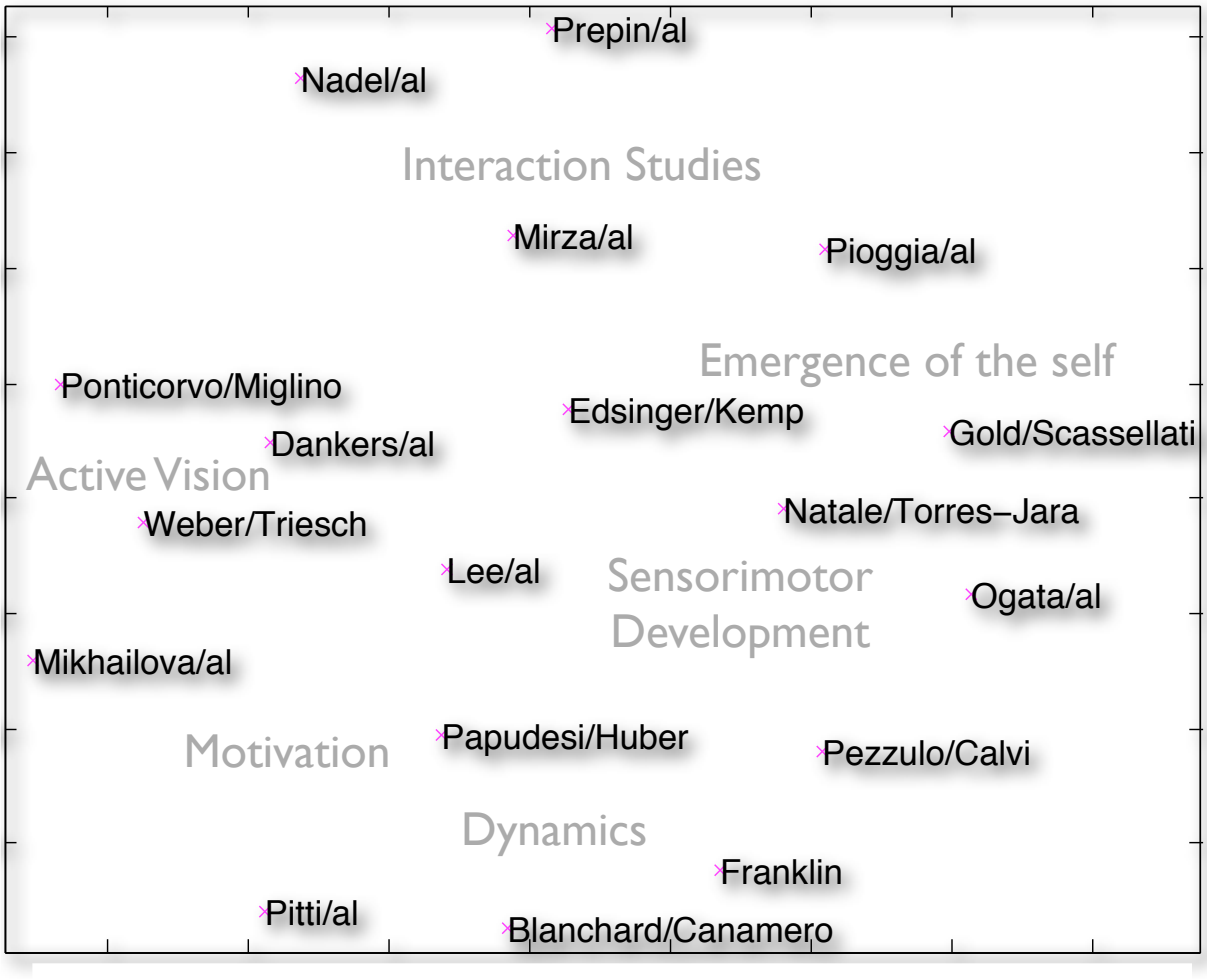

Figure 7: Two dimensional map obtained by multi-dimensional scaling reflecting the relative distance between papers in the proceedings