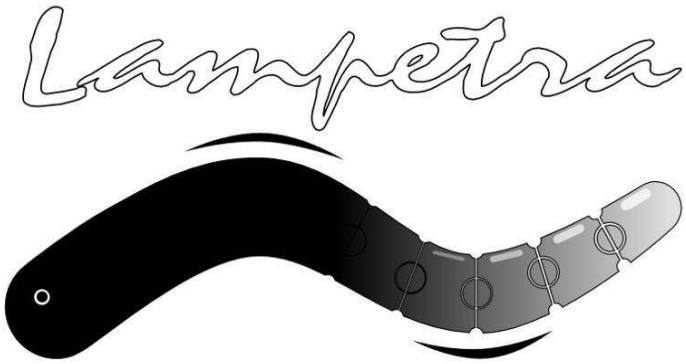
SEVENTH FRAMEWORK PROGRAMME
THEME ICT-2007.8.3 - FET proactive 3
"Bio-ICT convergence"

Grant agreement for: **Collaborative Project**
(small or medium-scale focused research project)

Project acronym: LAMPETRA
Project full title: Life-like Artefacts for Motor-Postural Experiments and Development of new Control Technologies inspired by Rapid Animal locomotion



Grant agreement no.: 216100

Project Deliverable D9.4:

Report on dissemination, collaboration and exploitation

Involved period: **From month 25to month 42 (February 1, 2010 – July 31,2011)**
Date of issue: **July 31, 2011**
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1. Objectives of WP9

The objectives of Work Package WP9 are the following:

(1) to promote and distribute scientific publications

(2) to promote and share the technological developments and scientific results resulting from the LAMPETRA project with the scientific community

(3) to promote the results to the media and the general public

(4) to promote joint collaboration between LAMPETRA and other FET-Proactive projects, exploiting all possible synergies, thus increasing the impact of the proposed research and of the FET-Proactive Initiative.

2. General summary

The last 18 months of the project have led to very active dissemination activities. LAMPETRA has been involved in the organization of symposiums, workshops, and summer schools. In particular, it has co-organized with the ANGELs project an International Workshop on Bio-Inspired Robots from April 6 to 8, 2011 in Nantes, see http://www.emn.fr/z-dre/bionic-robots-workshop/

Furthermore, LAMPETRA partners have published over 15 papers in journals and conference proceedings, and guess edited two special issues (one in *Autonomous Robots* and one in *Bioinspiration & Biomimetics*).

The results of LAMPETRA have been featured extensively in national and international media, with both TV (BBC, France 3, Swiss German TV, Swiss Italian TV) and newspaper (The Economist, Sole 24 Ore, Le Figaro, Ouest-France, L'Expess, Sud-Ouest) coverage.

Also noteworthy is that two PhD students participating to LAMPETRA, Jeremie Knuesel and Andrej Bicanski have received prizes corresponding to the top 5% abstract and poster contributions for their participation to the Computational Neuroscience Meeting (CNS2011).

The LAMPETRA project website (www.lampetra.org) has been improved and constantly updated with photos and videos. Events in which the consortium was involved for showing the scientific results of the project or have demos with the robot (e.g FET11) have been widely advertised. Compared with the first two years of the project in which visits at the website pages were around 8000 accesses have more than doubled: actually they are roughly 17650. This result is an objective fact of how the consortium has done a good job in dissemination activities and of how the project and its results have been effectively advertised at the general public. In web search engines (e.g.: Google), our Project website is the first link if the words

- "Lampetra"
- "Lamprey artefact"
- "Swimming artefact"
- "Bio-inspired lamprey"

are typed.

3. Publications and patents

Publications:

- A.J. Ijspeert, P. Dario and S. Grillner. Guest editorial: special issue on control of locomotion—from animals to robots Autonomous Robots, vol. 28, num. 3, p. 245-246, 2010.

- D. Ryczko, V. Charrier, A. Ijspeert and J.-M. Cabelguen. Segmental Oscillators in Axial Motor Circuits of the Salamander: Distribution and Bursting Mechanisms Journal of Neurophysiology, vol. 104, p. 2677-2692, 2010.

- F. Li, W. Liu, C. Stefanini, X. Fu, P. Dario , A Novel Bioinspired PVDF Micro/Nano Hair Receptor for Robot Sensing System, Sensors, 10(1), 994-1011, 2010.

- J. Knuesel, J.-M. Cabelguen and A.J. Ijspeert, Decoding the mechanisms of gait generation and gait transition in the salamander using robots and mathematical models, in: Motor Control: Theories, Experiments and Applications, chapter 18, pp. 417-451, Oxford University Press, 2010.

- Cabelguen JM, Ijspeert A, Lamarque S, Ryczko D. : Axial dynamics during locomotion in vertebrates lesson from the salamander. Prog Brain Res 187: 149-62, 2010.

- Ryczko D, Dubuc R, Cabelguen JM: Rhythmogenesis in axial locomotor networks: an interspecies comparison. Prog Brain Res 187: 189-211, 2010.

- Harishandra N, Cabelguen J-M, Ekeberg O.: A 3D Musculo-Mechanical Model of the Salamander for the Study of Different Gaits and Modes of Locomotion. Frontiers in Neurorobotics 4: 112, 2010.

- Bicanski A., Ryczko D., Cabelguen J.-M., Ijspeert A.J., Modeling axial spinal segments of the salamander central pattern generator for locomotion, Abstract presented at the Twentieth Annual Computational Neuroscience Meeting, CNS 2011, BMC Neuroscience, Volume 12, Supplement 1, P157, 2011.

- Knuesel J., Ijspeert A.J., Effects of muscle dynamics and proprioceptive feedback on the kinematics and CPG activity of salamander stepping, Abstract presented at the Twentieth Annual Computational Neuroscience Meeting, CNS 2011, BMC Neuroscience, Volume 12, Supplement 1, P157, 2011.

- S.Orofino, S.Marrazza, T.Assaf, L.Manfredi, L.Capantini, S.Mintchev, C.Stefanini, P.Dario and S.Grillner, Validation of neural mechanisms through a bio-robotic artifact. Abstract for the International Workshop on Bioinspired Robots, Nantes, 2011.

- C.Stefanini, L.Manfredi, S.Orofino, S.Mintchev, S.Marrazza, T.Assaf, L.Capantini, U.Scarfogliero, E.Sinibaldi, and P.Dario, Development of a compliant, high-efficiency and bio-inspired snake-like swimming robot. Abstract for the International Workshop on Bioinspired Robots, Nantes, 2011

- S.Mintchev and C.Stefanini ,A novel muscle-like, high efficiency actuator for biorobotics. Abstract for the Workshop on Biologically Inspired Actuation – ICRA 2011

- Kamali Sarvestani I., Lindahl M., Hellgren Kotaleski J. and Ekeberg Ö. The arbitration-extension hypothesis: a hierarchical interpretation of the functional organization of the basal ganglia. Front. Syst. Neurosci.: 5, 13, 2011

- Planert, H., S.N. Szydlowski, J.J. Hjorth, S. Grillner, G. Silberberg, Dynamics of synaptic transmission between fast-spiking interneurons and striatal projection neurons of the direct and indirect pathways. J Neurosci. 30: 3499-3507, 2010

- Grillner S. Motor system of fish and cyclostomes In: Farrell A.P., (ed.) Encyclopedia of Fish Physiology: From Genome to Environment. ISBN: 978-0-12-374545-3 Academic Press, 2011.

- Ericsson J., G. Silberberg, B. Robertson, MA Wikström, S. Grillner, Striatal cellular properties conserved from lampreys to mammals. J. Physiol. 589;2979-2992, 2011.

- Stephenson-Jones M, E. Samuelsson, J. Ericsson, B. Robertson and S. Grillner, Evolutionary conservation of the basal ganglia as a common vertebrate mechanism for action selection. Curr. Biol., 21;1081-1091, 2011.

Publications in press:

- C Stefanini, S Orofino, L Manfredi, S Mintchev, S Marrazza, T Assaf, L Capantini, E Sinibaldi, S Grillner, P Wallén and P Dario, A novel autonomous, bioinspired swimming robot developed by neuroscientists and bioengineers. Bioinspiration and Biomimetics, in press

Publications under review:

- Crespi A., Karakasiliotis K., Ijspeert A.J. Salamandra robotica II: an amphibious salamander robot controlled by a central pattern generator. IEEE Transations in Robotics.

- Harishandra N, Knüsel J., Kozlov A., Bicanski A., Cabelguen J-M, Ijspeert A., Ekeberg O.: Sensory feedback plays a significant role in generating walking gait and in gait transition in salamanders: a simulation study. Frontiers in Neurorobotics

Publications about to be submitted:

- Bicanski A., Ryczko D., Cabelguen J.-M., Ijspeert A.J. Modeling salamander axial spinal segments

- Ryczko D., Knüsel J., Lamarque S., Mathou A., Ijspeert A. J., Cabelguen J.M.: Locomotion underwater and on land with multifunctional circuits.

PhD thesis:

Scientific work related to the LAMPETRA project is documented through the PhD thesis "Development and demonstration of enabling subsystems for sensory-motor control of autonomous bioinspired artefacts" defended by T. Assaf at Scuola Superiore Sant'Anna (May 2011).

4. Participation to scientific events

Partners have presented LAMPETRA results to various scientific events. Scientific presentations include (in chronological order):

- Presentation by Nalin Harischandra at EPFL, "Neuro-Mechanical Simulations in the Study of Locomotion", Lausanne, Swizterland, April 4 2010
- Invited talk by Auke Ijspeert at "La Lamproie dans tous ses états », Cap Sciences, Bordeaux, 24 April 2010.
- Invited talk by Auke Ijspeert at the Embodied Intelligence Summer School, Livorno, September 21, 2010.
- Presentation by Iman Kamali Sarvestani at the Royal Institute of Technology, "Selection system and Boolean Machinery of the Basal Ganglia in Decision Making Processes", Stockholm, Sweden, October 22 2010
- Invited talk by Auke Ijspeert at Biomimetics 2011, Berlin, March 17 2011
- Invited talk by Iman Kamali Sarvestani, "The Arbitration-Extension hypothesis: A Mode of Basal Ganglia Functional Organization", Montreal, Quebec, Canada, March 25 2011
- Presentation by Iman Kamali Sarvestani at Concordia University, "The Arbitration-Extension hypothesis: A Mode of Basal Ganglia Functional Organization", Toronto, Ontario, Canada, March 29 2011
- Invited talk by Iman Kamali Sarvestani at the University of Western Ontario, "The Arbitration-Extension hypothesis: A Mode of Basal Ganglia Functional Organization", London, Ontario, Canada, March 29 2011
- Keynote talk by Cesare Stefanini at the International Workshop on Bioinspired Robots, April 6-8 2011, Nantes, France
- Keynote talk by Sten Grillner at the International Workshop on Bioinspired Robots, April 6-8 2011, Nantes, France
- Invited talk by Stefano Orofino at the International Workshop on Bioinspired Robots, April 6-8 2011, Nantes, France
- Invited talk by Luigi Manfredi at the International Workshop on Bioinspired Robots, April 6-8 2011, Nantes, France
- Keynote talk by Cesare Stefanini at the International Workshop on Biologically Inspired Actuation – ICRA 2011, May 13 2011, Shanghai, China
- Invited talk by Stefano Mintchev at the International Workshop on Biologically Inspired Actuation – ICRA 2011, May 13 2011, Shanghai, China

- Invited talk by Örjan Ekeberg at ETH, "Modeling Neuronal Control in the LAMPETRA Project", Zürich, Switzerland, June 2011
- Keynote talk by Auke Ijspeert at the 7th conference of the European Society for Fuzzy Logic and Technology (EUSFLAT-2011), Aix Les Bains, July 20, 2011
- Presentation by Nalin Harischandra at the Central Pattern Generator workshop at the Twentieth Annual Computational Neuroscience Meeeting, CNS 2011, "Modeling Locomotor CPG: From Simple to Complex (A Case Study)", Stockholm, July 27 2011
- Invited talk by Auke Ijspeert at the Central Pattern Generator workshop at the Twentieth Annual Computational Neuroscience Meeting, CNS 2011, Stockholm, July 27 2011

Abstract/poster presentations

- Charrier V, Cabelguen JM : Fictive rhythmic motor patterns generated in tail segments of the adult salamander . SfN Abstract 3766, Washington, 2011.
- Charrier V, Cabelguen JM : Fictive rhythmic motor patterns generated in tail segments of the adult salamander. 5th Satellite Symposium on Motor System, Washington, 2011.
- Charrier V, Lamarque S, Ryczko D, Cabelguen JM : Kinematics and electromyographical analysis of the adaptation of locomotor movements in the salamander. 7th FENS forum of European Neuroscience, Amsterdam, 2010.
- Charrier V, Lamarque S, Ryczko D, Cabelguen JM :Kinematics and electromyographical analysis of the adaptation of locomotor movements in the salamander. Symposium of Neurocentre Magendie, Bordeaux, 2010.
- Bicanski A., Ryczko D., Cabelguen J.-M., Ijspeert A.J., Modeling axial spinal segments of the salamander central pattern generator for locomotion, Twentieth Annual Computational Neuroscience Meeting, CNS 2011, Stockholm 2011.
- Knuesel J., Ijspeert A.J., Effects of muscle dynamics and proprioceptive feedback on the kinematics and CPG activity of salamander stepping, Twentieth Annual Computational Neuroscience Meeting, CNS 2011, Stockholm 2011.
- Kardamakis, AA, Stephenson Jones M, Robertson B and Grillner S. Tectoreticular pathway and its link to visuomotor control. Poster at the IBRO meeting, Firenze 2011.

Furthermore, LAMPETRA has participated to the FET 11 conference (May 4-6 2011). We have proposed an exhibition, which has been successfully selected. We were one of the 30 stands there, with live demos of the SSSA and EPFL robots. The aim of the exhibition was to disseminate the main objectives and outcomes (achieved, in progress and expected) of the LAMPETRA project, so as to interact with a wider FET audience.

5. Demonstrations of the artefacts

- FET11 (4-6 May 2011, Budapest)
- Journée de la robotique 2011, May 2011 at EPFL.

- International Workshop on Bio-inspired Robots (6-8 April 2011, Nantes), see http://www.emn.fr/z-sic/videos/Bionic-Robots-Workshop/bionic-robots-workshop-9minutes.flv
- RomeCup 2011 (16 March 2011, Rome, Italy), http://www.mondodigitale.org/news/2011/03/la-ricerca-fantasma
- X mostra del film scientifico e tecnologico (25-30 May 2010, Rovereto, Italy)
- "La Lamproie dans tous ses états », Cap Sciences, Bordeaux, 24 April 2010
- Exhibitions at public swimming pool in Pontedera and in Cascina for general public.
- LEGO idea conference (14 April 2010)
- Multiple demonstrations at SSSA
- Multiple demonstrations at EPFL

6. Organized and co-sponsored events

Lampetra Partners have been actively involved in organizing and co-sponsoring events. In particular the co-organization with ANGELs partners of the International Workshop on Bioinspired Robots that took place on April 6-8 2011, in Nantes France was a great success with over 200 international participants.

- International Workshop on Bioinspired Robots, April 6-8 2011, Nantes, France http://www.emn.fr/z-dre/bionic-robots-workshop/
- International Workshop on Biologically Inspired Actuation – ICRA 2011, May 13 2011, Shanghai, China http://www.me.gatech.edu/biorobo/icra2011workshop/
- Second Summer School on Embodied Intelligence and Lampetra, June 27 – July 1 2011, Zurich, Switzerland http://www.octopus-project.eu/Zurich_EI_%20summerschool.html
- "La Lamproie dans tous ses états », Cap Sciences, Bordeaux, 24 April 2010.

7. Media coverage

The results of the LAMPETRA project have appeared in the following media:

- "Nello zoo-robot dove le macchine imparano dalla natura" Sole 24 Ore - Italian newspaper, July 17 2011 http://www.ilsole24ore.com/art/tecnologie/2011-07-15/nello-zoorobot-dove-macchine-182253.shtml?uuid=AaiyQPoD
- "Zoobotics - A new generation of animal-like robots is about to emerge from the laboratory" The Economist July 7 2011 http://www.economist.com/node/18925855
- BBC, show featuring highlights of the FET conference in Budapest, May 2011 http://news.bbc.co.uk/2/hi/programmes/click_online/9491296.stm
- "Robots at Work and play" - The Atlantic April 22 2011 http://www.theatlantic.com/infocus/2011/04/robots-at-work-and-play/100052/
- "Les biorobots imitent les animaux" - Ouest-France, April 12 2011

- "Robots: imiter les animaux, une alternative à l'intelligence artificielle", April 12 2011 http://www.sciencesetavenir.fr/depeche/sciences/20110412.AFP8637/robots-imiter-les-animaux-une-alternative-a-l-intelligence-artificielle.html
- "Les animaux bioniques s'exhibent", April 8 2011 http://www.20minutes.fr/nantes/702949-nantes-les-animaux-bioniques-exhibent
- "Quand les robots imitent les animaux" - le Figaro, April 8 2011 http://www.lefigaro.fr/sciences/2011/04/08/01008-20110408ARTFIG00654-quand-les-robots-imitent-les-animaux.php
- « Les animaux bioniques étalent leur science », L'Express, April 8 2011, http://www.lexpress.fr/actualites/2/actualite/les-animaux-bioniques-etalent-leur-science_980669.html
- "Drole de bestiaire à Nantes" Presse-Océan, April 6 2011
- Documentary on the Swiss German TV program *Einstein*, December 2010
- Swiss Italian TV science program *Il giradino di Albert*. October 2010.
- Web TV, Inspired from Nature, May 2010 http://www.sperimentarea.tv/ondemand/la-lampreda-robotica-del-santanna-di-pisa-al-discovery-2010
- "La Lamproie star des labos", Sud-Ouest newspaper, April 2010, see http://biorob2.epfl.ch/download/pdf/BordeauxApril2010.pdf.
- TV special on RAI3 (Italian Channel) Geo&Geo: Bioinspired robots, April 29 2010 http://www.youtube.com/watch?v=DvHd2_Bu-ZI
- Documentary on the Swiss German TV program *Einstein*, December 2010
- Swiss Italian TV science program *Il giradino di Albert*. October 2010.

8. Interaction with other FET projects

In addition to our participation to the FET 11 conference, several interactions between LAMPETRA and other FET-Proactive projects have taken place. These include:

- The participation of Auke Ijspeert as invited speaker to Embodied Intelligence Summer School, Livorno, September 21, 2010.
- The organization of the International Workshop on Bio-inspired Robots (6-8 April 2011, Nantes) with the ANGELs project.
- The organization of the Second Summer School on Embodied Intelligence and Lampetra, June 27 – July 1 2011, Zurich, Switzerland with the EMBODy project.
- The participation of Orjan Ekeberg as invited speaker to that summer school
- The participation of Kostas Karakasiliotis (EPFL) to a study of lizard locomotion with partners from the LOCOMORPH project


Lampetra
Life-like Artefacts for Motor-Postural Experiments and Development of new Control Technologies inspired by Rapid Animal locomotion
Home | The Project | The team | Material | Events | Links | Media | Publications | Contact us
The LAMPETRA project aims at developing lamprey/salamander bioinspired artefacts to perform neuroscientific studies related to goal-directed locomotion, and to find innovative solutions for high-performance artificial locomotion, in terms of fast-response, adaptability, reliability, energy efficiency and control. The project is expected to achieve advances in neurosciences, technology and engineering, including control.
The original approach towards these goals is based on the development and use of bioinspired lamprey/salamander artefacts for conducting neuroscientific studies and for performing bio-hybrid experiments on vertebrate mechanisms involved in the neural control of goal-directed locomotion, bringing new scientific knowledge in this field.
Besides the implementation of the bioinspired artificial system (mimicking the neuronal level, the biomechanical structure and the control functions), advanced numerical simulations are also performed, focused on the neural control system of locomotion.
LAMPETRA is a three-year collaborative project and has received funding from the European Community's Seventh Framework Programme (FP7, Theme ICT-2007.8.3 - FET proactive 3, "Bio-ICT Convergence").
Video Section...
... View!
Public Swimming Pool, Pontedera, Dec 2009
More details...
fet11 Science beyond fiction 4-6 May 2011 Budapest, Hungary
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1 7 6 3 6 Visits from April 2008

Swimming bio-inspired artefacts with 3D vision

LAMPETRA Project

LAMPETRA: Life-like Artefacts for Motor-Postural Experiments and Development of new Control Technologies inspired by Rapid Animal locomotion

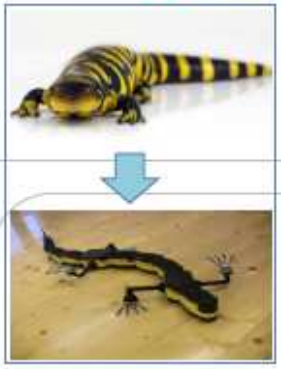
Lampetra Goals:

- to conduct **neuroscientific studies** on vertebrate mechanisms involved in the neural control of goal-directed locomotion;
- use of a lamprey artefact, for validating neuroscientific assumptions on vertebrate mechanisms involved in the neural control of goal-directed locomotion, including:
  - ✓ the selection between different patterns of behaviours based on visual input and other senses;
  - ✓ motivational control as in the case of hunger, aggression, sexual partner selection, day/night cycle.

www.lampetra.org

From Nature...

Lamprey and salamander represent perfect prototypes of vertebrate: their neural and motor systems are easy to study both *in vivo* and *in vitro* and, consequently, to model.



Thanks to the **hierarchical structure** of the neural and motor systems it has been possible to find out and then to describe the neuronal network that underlies the final output of their reciprocal interaction: locomotion.

... to Biorobotics

The artefacts can be considered a sort of natural undulatory system based on CPG control.

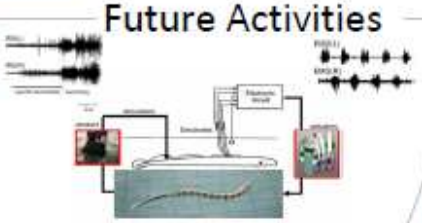
Main features	
Lenght	1m
Speed	0.7 m/s
Autonomy	5 hours +

Mechanical properties of skeletal apparatus and actuators stabilize the system during locomotion: a real biomimetic structure.

Physical artefacts provide a powerful addition to the methodological repertoire.

Compliant body

Future Activities



The proposed method consists of bidirectionally coupling the animal nervous system and the artefact. Activities of the main descending motor pathways are recorded and sent in real-time to CPG models on board of a freely moving artefact.

GOALS:

- to explore goal-directed behaviour in a controlled setting;
- to test the CPG models in a realistic setting;
- to explore interaction of different sensor modalities;
- to measure the activity of descending commands, with the verification of control hypotheses (e.g. comparison between steady-state and non-steady-state locomotion);
- to perturb some modalities and not others, and see how it affects behaviour.