Project No. 231724

HUman behavioral Modeling for enhancing learning by Optimizing hUman-Robot interaction

HUMOUR

THEME 2: Cognitive Systems, Interaction, Robotics

Deliverable 1.2

Final Plan for the Use and Dissemination of Foreground

Due Date: Month 30
Submission date: Month 30

Start date of project: **01/01/2009** Duration: **36 months**

Lead beneficiary for this deliverable: AAU

Responsible Person: Dejan B. Popovic

Revision: **1.1**

Dissemination Level		
PU	Public	**V**
PP	Restricted to other programme participants (including the Commission Service)	
RE	Restricted to a group specified by the consortium (including the Commission Service)	
CO	Confidential, only for members of the consortium (including the Commission Service)	

Table of Contents

Outline

Deliverable 1.2 summarizes the body of new knowledge, new technologies and new applications generated (or expected to be generated) within the time span of the HUMOUR project. Section 1 describes the dissemination activities, planned or performed at consortium and partner level. Section 2 lists all the individual items (journal articles, conference papers, book chapters and patents) – updated to month 30.
Section 3 contains a list of exploitable results, with a synthetic description and an indication of the IPR information.

Section 1 Dissemination of knowledge

1.1 Dissemination at Consortium level

2010

The Consortium organized a Special Session on Rehabilitation Robotics (chairs: D. Popović and V. Sanguineti) within the XVIII International Society of Electrophysiology and Kinesiology (ISEK) Congress which took place in Aalborg, Denmark on June 16-19, 2010. The purpose of this special session was to disseminate the project's concept and initial results in the neuro-rehabilitation and kinesiology field.
The session was part of the regular conference program, and included contributions from all partners, plus additional contributions from other groups.
In the same occasion, several members of the Consortium contributed as lecturers in the Summer School on "Neurorehabilitation. Recovery of Motor Function".

2011

The Consortium is organizing a workshop on 'Motor skill learning and neuro-rehabilitation' (Organizers: V. Sanguineti, E. Burdet) within the IEEE International Conference on Rehabilitation Robotics (ICORR 2011), to be held in Zurich, Switzerland on June 29-July 1st. The workshop's main claim, directly derived from HUMOUR, is that studying how humans acquire novel motor skills (and how robots can be used to facilitate such learning) may suggest or test neuro-rehabilitation therapies and novel ways to use robots for rehabilitation.

The consortium has initiated a special issue in the IEEE TNSRE on "Motor skill learning and neuro-rehabilitation" (Eds. D. Popović, E. Burdet, V. Sanguineti and H. Heuer), i.e. computational neuroscience based rehabilitation, that is already advertised by the journal. The special issue is scheduled to appear in 2012.

An additional dissemination event related to the project is the organization of a special session on "What is motor skill and can technology enhance it?" (Organizers: JW Krakauer, V. Sanguineti) at the IEEE Engineering in Medicine and Biology Conference

(EMBC 2011), to be held in Boston, USA on Aug 20-Sep 1st, where some members of the consortium (E. Burdet, V. Sanguineti) will be speakers.

1.2 Dissemination at partner level

2009

1. Burdet E, d'Avella A, Ijspeert, A. European Science Foundation (ESF) Exploratory Workshop on "Modularity for Versatile Motor Learning: From Neuroscience to Robotics and Back". April 8-11, 2009.
2. Burdet, E. Course on Human Neuromuscular Control at University Paris VI in the context of the International Masters in Rehabilitation Robotics. Duration: 20h in 10-12/09
3. Burdet, E. Course on Robot-Assisted Neurorehabilitation, in the context of Health Manpower Development Plan (HMDP) of the Ministry of Health, Singapore, 30.11.09-4.12.09, organizer and lecturer.
4. Burdet E. 10 lectures on various aspects of robotics and neurotechnology at the context of the Academic Leaders Programme at one of the top Mexican Universities, Tecnologico de Monterrey, from March 30th, 2009 to April 3rd, 2009.
5. Burdet E. Keynote lecture on "Human Robotics" at the Hampstead Medical Society, UK, January 15, 2009.
6. Burdet E. "Robot-assisted rehabilitation of hand function with adapted sensorimotor and psychological feedbacks" at the International Neurorehabilitation Symposium (INRS), University Zurich, Switzerland, February 13, 2009. (invited lecture)
7. Burdet E. "Human Robotics", Computer Science Dept, Edinburgh University, UK, 9/3/09 (invited lecture)
8. Burdet E. "Human Robotics - from modelling of human motor function to robots for humans" at the Tecnologico de Monterrey, Campus Estado de Mexico, April 2nd, 2009. (plenary lecture)
9. Burdet E. "Human-centered rehabilitation robotics", at the International Convention for Rehabilitation Engineering and Assistive Technology, (i-Create07), Singapore, April 23, 2009. (keynote lecture)
10. Burdet E. "Biological Optimization in Human Motor Control" European Research Network Programme in Sensorimotor Function in Health and Disease (ERNI-HSF) Workshop on "Computational principles of sensorimotor learning", Kloster Irsee, Swabia, Germany, September 14-15, 2009. (lecture)

11. Heuer H., Rapp K.M. "Die zweimal hinschauen" - Psychologie und Arbeitsforschung [Those who look twice" - Psychology at work]". Seminar series on "Applied fields of Psychology". April 27, 2009, University of Munster (GERMANY).

12. Sanguineti, V. "Using robots to promote neuromotor recovery and motor skill learning." Italy-Japan International Seminar "Musculoskeletal System and Computational Neuroscience for Rehabilitation", June 15-18, 2009. Italian Institute of Technology, Genoa, Italy.

13. Sanguineti, V. "Utilizzo di robot aptici per accelerare l.apprendimento di compiti motori complessi e per favorire il recupero funzionale in pazienti con deficit neuromotorio" [Using haptic robots to accelerate motor skill learning and to facilitate functional recovery in patients with neuromotor impairment]. Workshop "Dal controllo motorio al training di forza", November 27-29, 2009, Lucca. Italy.

14. Burdet, E. "Neuroscience and its use for neurorehabilitation" at KT-Equal SPARC meeting on Robots supporting personal independence and rehabilitation, 24/11/09, University of Herdfordshire (invited lecture).

15. Ramos Murguialday A. "Brain Computer Interfaces for Neurorehabilitation" at Max Planck Campus Symposium Life Sciences in Tubingen; 6-November 2009; Tubingen; Germany (invited lecture)

16. Ramos Murguialday A. "Coupling BCI and Robotics for Stroke Rehabilitation" and organizer of the "Brain Machine Interfaces for Neuroprostheses and Robot Control" Workshop at the International Conference on Robotics and Automation ICRA 2009, May 12th, KOBE, Japan (invited lecture)

2010

1. Luttgen, J.and Rapp, K. "Robotic Guidance." Presentation and demonstration for students of the Universities of Bochum, Dortmund and Munster at different occasions

2. Ramos Murguialday A., 2nd Annual Symposium on Advances in Neural Rehabilitation Engineering, August 23rd to 25th, 2010, Aalborg, Denmark

3. Ramos Murguialday A., "Neural Encoding of Perception and Action", Feb 21st to 22nd, 2010, Tubingen, Germany.

4. Burdet E. Course on Human robotics, neuromechanical control and learning, 20h course given at University Paris VI, in the context of the International Masters in rehabilitation robotics, November-December 2010.

5. Burdet E. “Computational neuroscience as a tool for rehabilitation”, at the International workshop on Neuro Rehabilitation Tokyo Institute of Technology, February 15-16, 2010. (invited lecture)

6. Burdet E. “Brain Control Strategies to Navigate in Familiar Environments” at the UK-Japan workshop on Neural Interfaces, Newcastle University, February 25-26, 2010. (invited lecture)

7. Burdet E. “Robot-assisted rehabilitation of the hand function” at the Centro de Rehabilitacion Infantil, Mexico (CRIT-TELETON, http://www.emexico.gob.mx/wb2/eMex/eMex_Centro_de_Rehabilitacion_Teleton) on April 1st, 2009. (invited presentation)

8. Burdet E. “Robot-assisted rehabilitation of the hand function” at the (Mexican) Instituto Nacional de Rehabilitacion (INR, http://www.cnr.gob. mx/i_note_01.html) on April 3rd, 2009. (invited lecture)

9. Burdet E, "Neuroscience and its use for rehabilitation" in the DFG-Graduiertenkollegs "prometei" (www.prometei.de) at TU Berlin, April 22, 2010. (invited lecture)

10. Burdet E, “Robots can learn to control haptic interactions as humans do” at the Computational Motor Control Workshop at Ben-Gurion University of the Negev, June 16, 2010. (invited lecture)

11. Burdet E, “Rehabilitation robotics” and “Assistive robotics” at the International Convention for Rehabilitation Engineering and Assistive Technology, (i-Create10), Shanghai, China, July 24, 2010. (invited lecture)

12. Burdet E, “Human Robotics” at Shanghai Jiaotong University, China, July 26, 2010. (invited lecture)

13. Burdet E, “Human centered rehabilitation robotics” at Department of Rehabiliation, Shaihai Ruijin Hospital (http://www.rjh.com.cn/), Shanghai Rehabilitation Hospital, Shanghai, China, July 27, 2010. (invited lecture)

14. Heuer, H, “Motor learning.” Summer School “Neurorehabilitation. Recovery of Motor Function”, Aalborg 2010

15. Burdet E, “Human motor learning and neurorehabilitation”, Annual Symposium on Advances in Neural Rehabilitation Engineering, Aalborg University, August 24, 2010. (Invited lecture)

16. Burdet E, “Modularity for versatile motor learning” ESF Standing Committee for Physical & Engineering Sciences Strategic Workshop, Egelsbach, Germany, September 1, 2010. (Invited lecture)

17. Burdet E, “Rules of mechanical virtual reality and games for neurorehabilitation”, Engineering faculty, Melbourne University, Australia, October 14, 2010. (Invited lecture)

18. Colombo R. Neuroriabilitazione robot-assistita: trattamento, valutazione e modelli. In Atti del workshop “Neuroriabilitazione e terapie robot-assistite nell'arto superiore”, 26 Novembre 2010, Castel Goffredo (MN).

19. Sanguineti V. “Robots for Rehabilitation.” Summer School “eurorehabilitation. Recovery of Motor Function”, Aalborg 2010.

20. Sanguineti V. Riabilitazione robot-mediata e meccanismi di rinforzo dell’apprendimento motorio. Scuola di Formazione Societa’ Italiana di Riabilitazione Neurologica. Ancona, 1 Luglio 2010.

21. Sanguineti V. Optimal robot assistance for motor skill learning and rehabilitation. International Workshop on Neuro-Rehabilitation. Tokyo, 15-16 Feb 2010.

22. Sanguineti V. Mobility Studies at NeuroLab. European Study Tour on .Technology to transform mobility for people with a disability, Pisa, 18 Oct 2010.

23. Sterpi I, Mazzone A., Colombo R. Sviluppo di un. architettura multi-dispositivo per la riabilitazione robotizzata dell’arto superiore. In Atti del workshop “Neuroriabilitazione e terapie robot-assistite nell'arto superiore”, 26 Novembre 2010, Castel Goffredo (MN).

2011

A novel course on “Human Centred Design of Assistive and Rehabilitation Devices’”(H-CARD) has been launched at Imperial, in which engineering students learn to design rehabilitation systems and assistive devices, integrating mechatronics, human factors (based on some finding from HUMOUR) and computer games. This course is ongoing and a similar course will be organised at Tecnologico de Monterrey in Mexico.

1. Burdet E, “Neuroscience-based rehabilitation of the hand function” 3rd Workshop on Biomedical Engineering, University of Lisboa, April 16, 2011. (Invited lecture)

Section 2 Publishable Results

2.1 Journal papers

2009

1. Casadio, M., P. Giannoni, et al. (2009). "A proof of concept study for the integration of robot therapy with physiotherapy in the treatment of stroke patients." Clin Rehabil 23(3): 217-28.

2. Casadio, M., P. Morasso, et al. (2009). "Measuring functional recovery of hemiparetic subjects during gentle robot therapy." Measurement 42(8): 1176-1187.

3. Casadio, M., P. Morasso, et al. (2009). "Minimally assistive robot training for proprioception enhancement." Exp Brain Res 194(2): 219-31.

4. Casadio M, Giannoni P, Masia L, Morasso P, Sandini G, Sanguineti V, Squeri V, and Vergaro E. Robot therapy of the upper limb in stroke patients: preliminary experiences for the principle-based use of this technology. Func Neurol 24: 195-202, 2009

5. Delconte C, Pisano F, Tommasi MA, Cavalli A, Pianca D, Mazzone A, Minuco G, Colombo R. Robotics in Rehabilitation. G Ital Med Lav Ergon. 2009 Jan-Mar;31(1):115-23.

6. Gu, Y., Farina, D., Ramos Murguialday, A., Dremstrup, K., Montoya, P., Birbaumer, N. (2009). Offline identification of imagined speed of wrist movements in paralyzed ALS patients from single-trial EEG. Frontiers in Neuroprosthetics. DOI:10.3389/neuro.20.003.2009

7. Sülzenbrück, S. & Heuer, H.: Functional independence of explicit and implicit motor adjustments. Consciousness and Cognition, 2009, 18, 145-159.

8. Heuer, H. & Sülzenbrück, S.: Trajectories in operating a hand-held tool. Journal of Experimental Psychology: Human Perception and Performance, 2009, 35, 375-389

9. Sülzenbrück, S. & Heuer, H.: Learning the visuomotor transformation of virtual and real sliding levers: Simple approximations of complex transformations. Experimental Brain Research, 2009, 195, 153-165

10. Heuer, H. & Hegele, M.: Adjustment to a complex visuo-motor transformation at early and late working age. Ergonomics, 2009, 92, 1039-1054

11. Klisić D, Kostić M, Došen S, Popović DB, “Control of prehension for the transradial prosthesis: natural-like image recognition system.“ J Aut Control. 2009; 19(1):27-31.

12. Masia, L., M. Casadio, et al. (2009). "Performance adaptive training control strategy for recovering wrist movements in stroke patients: a preliminary, feasibility study." J Neuroeng Rehabil 6: 44.

13. Masia, L., M. Casadio, et al. (2009). "Eye-hand coordination during dynamic visuomotor rotations." PLoS One 4(9): e7004.

14. Mohan V, Morasso P, Metta G, Sandini G (2009) A biomimetic, force-field based computational model for motion planning and bimanual coordination in humanoid robots. Autonomous Robots, 27:291-307.

15. O.Sullivan I, Burdet E, Diedrichsen J (2009), Dissociating variability and effort as determinants of coordination. Plos Computational Biology 5(4): e1000345.

16. Safwat B, Su E, Gassert R, Teo CL and Burdet E (2009), The Role of Posture, Magnification and Grip Force on Microscopic Accuracy. Annals of Biomedical Engineering 37(5): 997-1006.

17. Squeri, V., M. Casadio, et al. (2009). Bilateral robot therapy based on haptics and reinforcement learning: Feasibility study of a new concept for treatment of patients after stroke. J Rehabil Med 41(12): 961-5.

18. Zeng Q, Burdet E and Teo CL (2009), Evaluation of a Collaborative Wheelchair System in Cerebral Palsy and Traumatic Brain Injury Users, Neurorehabilitation and Neural Repair 23(5): 494-504.

2010

1. Balasubramaniam S, J Klein and E Burdet (2010), Robot-assisted rehabilitation of hand function (2010), Current Opinion in Neurology 23(6): 661-70.

2. D. Brötz, C. Braun, C. Weber, S. Soekadar, A. Caria, N. Birbaumer Combination of Brain Computer-Interface Training and Goal Directed Active Physical Therapy of Chronic

Stroke: A Case Report. Neurorehabilitation and Neural Repair, 24(7) 674-679, 2010. DOI: 10.1177/1545968310368683

3. Caria, C. Weber, D. Brötz, A. Ramos, LF. Ticini, A Gharabaghi, C. Braun, N. Birbaumer Chronic stroke recovery after combined BCI training and physiotherapy. A case report. Psychophysiology, 2010. DOI: 10.1111/j.1469-8986.2010.01117.x

4. Casadio, M., Sanguineti, V., Squeri V, Masia L, Morasso P (2010) Inter-limb interference during bimanual adaptation to dynamic environments. Exp Brain Res 202(3):693-707.

5. Casadio M, Giannoni P, Masia L, Morasso P, Sanguineti V, Squeri V, Vergaro E (2010) Consciousness as the emergent property of the interaction between brain, body, and environment: implications for robot-enhanced neuromotor rehabilitation. Journal of Psychophysiology 24(2):125-130.

6. Colombo, R., I. Sterpi, et al. (2010). "Measuring Changes of Movement Dynamics During Robot-Aided Neurorehabilitation of Stroke Patients." IEEE Trans Neural Syst Rehabil Eng. 18:75-85.

7. Došen S, Cipriani C, Kostić M, Carrozza MC, Popović DB. „Cognitive vision system for the control of a dexterous prosthetic hand: An evaluation study." Journal of NeuroEngineering and Rehabilitation 2010, 7:42 doi:10.1186/1743-0003-7-42

8. Došen S, Popović DB. "Transradial Prosthesis: Artificial Vision for Control of Prehension." Artif Organs, 2010. DOI: 10.1111/j.1525-1594.2010.01040x

9. Dovat L, O Lambercy, B Salman, V Johnson, TE Milner, R Gassert, E Burdet and TC Leo (2010), A technique to train finger coordination and independence after stroke. Disability and Rehabilitation: Assistive Technology 5: 279-87.

10. Hegele, M. & Heuer, H. (2010). Adaptation to a direction-dependent visuomotor gain in the young and elderly. Psychological Research 74: 21-34

11. Hegele, M. & Heuer, H. (2010) The impact of augmented information on visuo-motor adaptation in younger and older adults. PLoS ONE 5(8): e12071

12. Hegele, M. & Heuer, H (2010). Implicit and explicit components of dual adaptation to visuomotor rotations. Consciousness and Cognition 19: 906-917

13. Heuer, H. & Hegele, M. (2010).The effects of mechanical transparency on adjustment to a complex visuo-motor transformation at early and late working age. Journal of Experimental Psychology: Applied 16: 399-412

14. Hegele, M. & Heuer, H.: Anpassung an visumotorische Transformationen unter indirekter Sicht in frühem und spätem Erwerbsalter. Zeitschrift für Arbeitswissenschaft, 2010, 64, 265-275

15. Iftime Nielsen SD, Došen S, Popović MB, Popović DB. „Learning Arm/Hand Coordination with an Altered Visual Input." Comp Intel Neurosci, 2010, Doi:10.1155/2010/520781, Hindawi Publishing Corporation, ID 520781, 12 pages

16. Kazemi H, Rappel JK, Poston T, Lim BH, Burdet E and Teo CL (2010), Assessing Suturing Techniques Using a Virtual Reality Simulator. Journal of Microsurgery 30(6): 479-86.

17. Morasso P, Casadio M, Mohan V, Zenzeri J (2010) A neural mechanism of synergy formation for whole body reaching. Biol Cybern 102:45-55

18. Squeri V, Masia L, Casadio M, Morasso P, Vergaro E. (2010) Force-field compensation in a manual tracking task. PLoS One 5(6):e11189.

19. Sülzenbrück, S. & Heuer, H. (2010). The trajectory of adaptation to the visuo-motor transformation of virtual and real sliding levers. Experimental Brain Research 201: 540-560

20. Vergaro E, Casadio M, Squeri V, Giannoni P, Morasso P, and Sanguineti V. Self-adaptive robot training of stroke survivors for continuous tracking movements. Journal of NeuroEngineering and Rehabilitation 7: 13, 2010.

21. Zhao G, Teo CL, Hutmacher DW and Burdet E (2010), Force controlled, automatic microassembly of tissue engineering scaffolds. Journal of Micromechanics and Microengineering 20(3) 035001.

2011

1. Novaković V, and Sanguineti V. (2011) Adaptation to constant-magnitude assistive forces: kinematic and neural correlates. Exp Brain Res 209(3):425-36.

2. Heuer, H. & Rapp, K.: Active error corrections enhance adaptation to a visuo-motor rotation. Experimental Brain Research, 2011, 211, 97-108

3. Sülzenbrück, S. & Heuer, H.: Type of visual feedback during practice influences the precision of the acquired internal model of a complex visuo-motor transformation. Ergonomics, 2011, 54, 34-46

In press

1. Heuer, H., Hegele, M. & Sülzenbrück, S. (in press) Implicit and explicit adjustments to extrinsic visuo-motor transformations and their age-related changes. Human Movement Science. doi:10.1016/j.humov.2010.07.004

2. Melendez-Calderon A, L Masia, R Gassert, G Sandini and E Burdet (in press), Feedforward learned without proprioceptive error transfers well to the real task, IEEE Transactions on Neural Systems and Rehabilitation Engineering.

3. Su ELM, Ganesh G, Yeong CF, Teo CL, Ang WT and Burdet E (in press), Effects of grip force and training in unstable dynamics on accuracy in micromanipulation, IEEE Transactions on Haptics.

4. Balasubramaniam S, Colombo R, Sanguinetti V and Burdet E (in press), Robotic assessment of motor function after stroke, American Journal of Physical Medicine & Rehabilitation.

2.2 Book chapters

2009

1. Birbaumer, N., Ramos Murguialday, A., Weber, C., Montoya, P. (2009). Neurofeedback and Brain-Computer-Interface: clinical applications. In: L. Rossini, D. Izzo, L. Summerer (eds.): Brain-Machine-Interfaces for Space Application. International Review of Neurobiology. Elsevier, Amsterdam, 107-117.

2. Sanguineti, V., M. Casadio, et al. (2009). "Robot therapy for stroke survivors: proprioceptive training and regulation of assistance." Stud Health Technol Inform **145**: 126-42.

3. Soekadar S, Caria A, Ramos Murguialday A, Birbaumer N. Rehabilitation after stroke using brain-computer-interfaces and neurostimulation. In: N. Johnsen and Rolf Agerskov (ed.), Somatosensory Cortex: Roles, Interventions and Traumas. Nova Science Publ., New York. 2009. ISBN 978-1-60741-876-4.

2010

1. Heuer, H.: Motor control. In: I.B.Weiner & W.E.Craighead (Eds.): The Corsini Encyclopedia of Psychology, Fourth Edition, Volume 3. New York: Wiley 2010 (pp. 1034-1035)

2. Birbaumer, N., Ramos Murguialday, A., Straub, A., Cohen, L. (2010). Gehirn-Computer-Schnittstellen bei Lähmungen. In: K.-H. Pantke (Hrsg.): Mensch und Maschine: Wie Brain-Computer-Interfaces und andere Innovationen gelähmten Menschen kommunizieren helfen. Mabuse-Verlag, Frankfurt a.M., pp. 115-129.

3. Birbaumer, N., Ramos Murguialday, A., Cohen, L. (2010). Brain-Computer-Interface (BCI) in paralysis. In: H.-C. Günther/ A.A. Robiglio (eds), The European Image of God and Man. A Contribution to the Debate on Human Rights. (Studies on the) I(interaction of)A(rt)T(hought and) P(ower) bei Brill (Leiden-Boston), pp.483-492.

4. Birbaumer N, Caria A, Piccione F, Sauseng P. Brain-Computer Interface in Neurorehabilitation. In: B. Graimann and G. Pfurtscheller (Eds),Brain-Computer Interfaces. Springer, New York. 2010.

5. Colombo R. Tecniche Neurorobotiche:applicazioni alle malattie neurodegenerative- In L‟evoluzione della riabilitazione per le malattie neurodegenerative”. M. Monticone ed. Aggiornamenti in Riabilitazione Vol 18, 2010; 113-124.

2011/In press

1. Lambercy O, L Dovat, B Salman, R Gassert, TE Milner, E Burdet and CL Teo (2011), Robot-assisted Rehabilitation of Hand Function After Stroke with the HapticKnob and the HandCARE. Biomechatronics in Medicine and Health Care. L Li and KY Tong eds, Pan Stanford Publishing Pte Ltd.

2.3 Conference papers

2009

1. Ananda ES, WT Latt, CY Shee, E Burdet, TC Lim, CL Teo, WT Ang (2009), E ect of Visual Feedback and Speed on Accuracy in Micromanipulation Tasks. Proc Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) 1:1188-91.

2. Basteris A., Vergaro E., Sanguineti V. (2009) Learning to throw. Progress in Motor Control conference, Marseille (France), March 2009.

3. Basteris A., Vergaro E., Sanguineti V. (2009) Direction-dependent performance in a robot-assisted putting task. Annual Meeting of the Society for Neuroscience, Chicago, October 2009.

4. Casadio, M., P. G. Morasso, et al. (2009). Modeling the dynamics of recovery in robot-assisted rehabilitation. World Congress on Medical Physics and Biomedical Engineering, Munich, Germany.

5. Casadio M., Novakovic V., Sanguineti V. (2009) Modelling the dynamics of motor recovery in robot therapy. 19th Annual Conference of the Neural Control of Movement Society NCM 2009, Hawaii, USA.

6. Casadio, M., V. Novakovic, et al. (2009). Modeling the dynamics of the recovery process in robot therapy. 2009 Virtual Rehabilitation International Conference, Haifa, Israel.

7. Casadio, M., P. Giannoni, et al. (2009). "Training stroke patients with continuous tracking movements: Evaluating the improvement of voluntary control." Conf Proc IEEE Eng Med Biol Soc 1: 5961-4.

8. Colombo R., Sterpi I., Mazzone A., Delconte C., Pisano F. Studio del recupero motorio mediante misure di performance eseguite durante riabilitazione robotizzata. Atti del Workshop "Neuroriabilitazione e Robotica", Genova, 14-15 Dicembre 2009.

9. Delconte C., Pisano F., Tommasi M.A., Pianca D., Colombo R. Robot-aided rehabilitation in severe brain injury. Conference of the “Società Italiana Neurofisiologia Clinica” (SINC), Salerno, 28-30 May, 2009.

10. Lambercy O, L Dovat, H Yun, SK Wee, CW Kuah, KS Chua, R Gassert, TE Milner, E. Burdet and CL Teo (2009), Exercises for Rehabilitation and Assessment of Hand Motor Function with the Haptic Knob. Proc International Convention for Rehabilitation Engineering and Assistive Technology (i-Create).

11. Lambercy O, L Dovat, H Yun, SK Wee, CW Kuah, KS Chua, R Gassert, TE Milner, CL Teo and E Burdet (2009), Rehabilitation of Grasping and Forearm Pronation/Supination with the Haptic Knob. Proc IEEE International Conference on Rehabilitation Robotics (ICORR) 22-7 (best presentation paper award).

12. Masia L, Squeri V , Casadio M, Morasso P, Sanguineti, V, Sandini G (2009) Tracking target motion under combined visual and kinesthetic disturbances. ICORR 2009, Kyoto

13. Melendez-Calderon A, L Masia, M Casadio and E Burdet (2009), Force field compensation can be learned without proprioceptive error. Proc Medical Physics and Biomedical Engineering World Congress 381-4.

14. Novakovic V., Sanguineti V., Morasso P. (2009). Effect of assistive force on motor imagery during reaching movements. Annual Meeting of the Society for Neuroscience, Chicago, October 2009.

15. Ramos, E. Soares, M. Agostini, D. Broetz, B. Benkner, M. Rea, S. Halder, A. Caria, S. Soekader, N. Birbaumer (2009) Afferent Feedback Influences for an On-Line BCI for Stroke Rehabilitation. 49th Annual Meeting of the Society for Psychophysiological Research SPR, Berlin, Germany, October 21-24, 2009. (Abstract)

16. Ramos, A. Caria, S. Soekader, S. Halder, S. Kofler, N. Birbaumer (2009) Proprioceptive Feedback in BCI. 4th International IEEE/EMBS Conference on Neural Engineering (NER) Antalya, Turkey, 29.04 – 02.05, 2009.

17. A. Ramos Murguialday, E. Soares, M. Agostini, D. Broetz, B. Benkner, M. Rea, S. Halder, S. Soekadar, N. Birbaumer; Afferent Feedback Influences for an On-Line BCI for Stroke Rehabilitation; Society for Psychophysiological Research 49th Annual Meeting, Berlin, Germany, 2009. (Abstract)

18. A. Ramos Murguialday, S. Halder and N. Birbaumer (2009) Propioceptive Feedback in BCI. In proceedings of NER'09, 4th International IEEE EMBS Conference on Neural Engineering, Antalya, Turkey, 2009.

19. Saha D., Sanguineti V., Mussa Ivaldi F.A. (2009) Redundancy in bimanual control of an object with inhomogenous mass distribution. Annual Meeting of the Society for Neuroscience, Chicago, October 2009.

20. Sanguineti V., Popovic D., Colombo R., Birbaumer N, Heuer H, Burdet E (2010) HUman behavioral Modeling for enhancing learning by Optimizing hUman-Robot interaction (HUMOUR): concept and preliminary results. 4th International Conference on Cognitive Systems, Zurich (Switzerland), 27-28 January 2010

21. Sterpi I., Imarisio C., Balia G., Galli S., Zancan A., Maffi G., Grioni G. Applicazione clinica dei dispositivi robotici inmotion: risultati preliminari. Atti del IV Congresso Nazionale SIRAS, 26-27 Novembre 2009.

22. Sterpi, I., A. Mazzone, et al. (2009). Sviluppo di un' architettura multi dispositivo con modello di assistenza progressiva per la riabilitazione robotizzata dell'arto superiore. IV Congresso Nazionale SIRAS, Pavia, Italy.

23. Sterpi I., Mazzone A., Basteris A., Sanguineti V., Colombo R. Development of a multidevice robot-aided rehabilitation architecture using progressive assistance regulation. Atti del . Atti del Workshop "Neuroriabilitazione e Robotica", Genova, 14-15 Dicembre 2009.

24. Sterpi I., Nilsson J., Colombo R. Development of a user interface for the management of the inmotion robotic devices in a network configuration. Atti del Workshop "Neuroriabilitazione e Robotica", Genova, 14-15 Dicembre 2009.

25. Sterpi, I., J. Nilsson, et al. (2009). Sviluppo di un' interfaccia per la gestione in rete di dispositivi robotizzati per riabilitazione. IV Congresso Nazionale SIRAS, Pavia, Italy.

26. Sterpi I., Castagna M., Maffi G., Grioni G., Galli S., Zancan A., Imarisio C., Balia G., Colombo R. Clinical application of inmotion robotic devices: preliminary results. Atti del Workshop "Neuroriabilitazione e Robotica", Genova, 14-15 Dicembre 2009.

27. Su ELM , TL Win , WT Ang , TC Lim, CL Teo and E Burdet (2009), Micromanipulation Accuracy in Pointing and Tracing Investigated with a Contact-Free Measurement System. Proc Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) 1: 3960-3.

28. Yeong CF, A. Melendez-Calderon and E. Burdet (2009), Analysis of pick-and-place, eating and drinking movements for the workspace definition of simple robotic devices, Proc IEEE International Conference on Rehabilitation Robotics (ICORR) 46-52.

2010

1. Basteris A., Bracco L., Sanguineti V. (2010) Robot-assisted learning of redundant tasks. 4th International Conference on Cognitive Systems, Zurich (Switzerland), 27-28 January 2010.

2. Basteris A, Dosen S, Sterpi I, Sanguineti V. An open-source, multi-robot software platform to support robot-assisted motor skill learning and rehabilitation exercises. In Atti del Secondo Congresso Nazionale di Bioingegneria - Torino, 8-10 Luglio 2010.

3. Basteris, A.; Bracco, L.; Sanguineti, V. (2010) Intermanual transfer of handwriting skills: role of visual and haptic assistance, in IMEKO Tc19 International Symposium on Human Function, Prague, Czech Republic

4. Basteris, A.; Bracco, L.; Sanguineti, V. (2010) Robot-assisted transfer of handwriting skills to the non-dominant hand, in Annual Meeting of the Society for Neuroscience, San Diego, USA

5. Basteris A, Bracco L, Sanguineti V (2010) Robot-assisted acquisition of handwriting skills in ISEK 2010 Conference, 16-19 June, Aalborg, Denmark

6. M. Beckmann, A. Caria, L. Laer, V. Kumar, A. Ramos Murguialday, N. Birbaumer, A. Gharabaghi; Motor network connectivity in chronic stroke patients with complete functional loss of wrist and finger extension a diffusion tractography-based evaluation; NeuroWoche 2010, Mannheim 21-25.9.2010; P 671 (Abstract)

7. Colombo R., Sterpi I., Delconte C., Mazzone A., Pisano F. Assessing changes of movement kinematics and dynamics during robot-aided neurorehabilitation. In Proceeding of the XVIII Congress of the International Society of Electrophysiology and Kinesiology (ISEK), 16-19 June 2010, Aalborg, Denmark.

8. Dosen S, Andersen A.H, Kannik K.E, Klausen C.S, Nielsen L, Wojtowicz J, Popovic DB. □’Assistive’ Forces for the Acquisition of a Motor Skill: Assistance or Disturbance?□h Proc. of the 1st International Conference on Applied Bionics and Biomechanics ICABB-2010, October 14-16 2010, Venice, Italy, CD

9. F. Grimm, D. Milford, A. Walter, Z. Zhou, G. Naros, A. Ramos Murguialday, A. Gharabaghi; Orthosis training of patients with severe hemiparesis applying EEG-triggered functional electrical stimulation; NeuroWoche 2010, Mannheim 21-25.9.2010; P 552 (Abstract)

10. Kostic M, Popovic DB. �Action Representation for Wii Bowling: Classification.�Proc of the 10th Symp Neural Network Applications in Electric Engineering, NEUREL 2010, September 23-25, 2010, Belgrade, Serbia, pp. 23-26, ISBN 3-900928-09-5.

11. L. Laer, A. Caria, A. Ramos Murguialday, N. Birbaumer, A. Gharabaghi; Resting state fMRI in chronic stroke; NeuroWoche 2010, Mannheim 21-25.9.2010; P 674 (Abstract)

12. Lambercy O, L Dovat, Y Hong, SK Wee, CWK Kuah, KSG Chua, R Gassert, T Milner, CL Teo and E Burdet (2010), Proc Asia-Oceania Conference of Physical Medicine and Rehabilitation (best poster award).

13. Lambercy O, L Dovat, H Yun, SK Wee, C Kuah, K Chua, R Gassert, TE Milner, CL Teo and E Burdet (2010), Robotic Assessment of Hand Function with the HapticKnob. Proc. International Convention on Rehabilitation Engineering and Assistive Technology (i-CREATe).

14. Popović DB, Kostić M, Popović MB, Došen S. “Mechanisms for integrating the “Wii-Game” and robot for the training of upper extremities in hemiplegics, Proc of the 17th ISEK Conf., June 16-19 2010, Aalborg (Abstract)

15. Ramos Murguialday A, A. Walter, E. Soares, D. Broetz, A. Gharabaghi and N. Birbaumer; Upper Limb Electromyography Decoding in Paralyzed Stroke Patients. Society for Neuroscience Meeting 2010; San Diego; USA. (Abstract)

16. Ramos Murguialday A., Halder S., Caria A., Birbaumer N; Haptic Feedback Influence in BCI; The XVIII Congress of the International Society of Electrophysiology and Kinesiology; Aalborg, Denmark 2010. (Abstract)

17. Ramos Murguialday; E. Soares; N. Birbaumer; Upper Limb EMG Artefact Rejection in Motor Sensitive BCIs; Engineering in Medicine and Biology Society (EMBC) Proceedings, 2010 Annual International Conference of the IEEE 2010.

18. Rapp, K.: Robot-Assisted Learning of a Visuo-Motor Transformation Task. Perception & Action, Bielefeld 2010

19. Rapp, K. & Heuer, H.: Force-field guidance in learning kinematic transformations. 4th International Conference on Cognitive Systems, Zurich (Switzerland), 27-28 January 2010.

20. Rapp, K. & Heuer, H.: Limitations of robot-guided motor learning. ISEK 2010, Aalborg 2010

21. Rapp, K. & Heuer, H.: Force-field guidance in learning kinematic transformations. CogSys2010, 4th International Conference on Cognitice Systems, Zürich 2010

22. Heuer, H.: Motor learning. Summer School "Neurorehabilitation – Recovery of Motor Function", Aalborg 2010

23. Rapp, K. & Heuer, H.: Limitations of robot-guided motor learning. ISEK 2010, Aalborg 2010Salman B, S Vahdat, O Lambercy, L Dovat, E Burdet and TE Milner (2010), Changes in Muscle Activation Patterns Following Robot-assisted Training of Hand Function after Stroke. Proc IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 5145-50.

24. Sanguineti V., Popovic D., Colombo R., Birbaumer N., Heuer H., Burdet E. The HUMOUR project: concept and initial results" In Proceedings of the 4th International Conference on Cognitive Systems (CogSys2010), Zurich (CH).

25. Schürholz M, Sitaram R, Birbaumer N, Caria A (2010) Online decoding of reaching and grasping movements using functional NIRS. 16th Annual Meeting of the Organization for Human Brain Mapping, 2010, Barcelona, Spain, 856 MT-PM. (Abstract)

26. M. Schürmeyer, A. Roth, G. Naros, A. Walter, A. Ramos Murguialday, A. Gharabaghi; Quantification of minimal hand/finger extension during neurorehabilitation of severely impaired hemiparetic patients. NeuroWoche 2010, Mannheim 21-25.9.2010; P 554 (Abstract)

27. Sterpi I., Mazzone A., Basteris A., Sanguineti V., Colombo R. Development of a multidevice robot-aided rehabilitation architecture. In Proceeding of the XVIII Congress of the International Society of Electrophysiology and Kinesiology (ISEK), 16-19 June 2010, Aalborg, Denmark.

28. Su ELM, G Ganesh, CF Yeong and E Burdet (2010), Accurate Micromanipulation induced by Performing in Unstable Dynamics. Proc IEEE International Symposium in Robot and Human Interactive Communication (Ro-Man) 762-6.

29. Yeong CF, K Baker, A Melendez, E Burdet and ED Playford (2010), ReachMAN robot for training reaching and manipulation in subacute stroke patients. Proc International Society of Electrophysiology and Kinesiology Congress (ISEK).

30. Yeong CF, A Melendez, E Burdet, K Baker and ED Playford (2010), ReachMAN to help sub-acute patients training reaching and manipulation. Proc IEEE International Conferences on Cybernetics and Intelligent Systems Robotics, Automation and Mechatronics (CIS-RAM) 90-5.

31. Yilmaz Ö., Sanchez-Nacher N., Walter A., Milford D., Soekadar S., Ramos Murguialday A., Birbaumer; N. Slow Cortical Potentials Preceding Different Modes of Movement. Society for Neuroscience Meeting 2010; San Diego; USA. (Abstract)

32. Z. Zhou, F. Grimm, D. Milford, A. Walter, A. Ramos Murguialday, A. Gharabaghi; Three-dimensional virtual arm feedback for orthosis-aided rehabilitation of haemiparetic patients. NeuroWoche 2010, Mannheim 21-25.9.2010; P 557 (Abstract)

2011/In press

1. D. Weiss, R. Klotz,A. Ramos Murguialday, G. Naros, F. Grimm, F. Bunjes, T. Gasser, T. Wächter, S. Breit, R. Kürger, A. Gharabaghi; Co-activation of antagonistic muscles in Parkinson's disease as a pathophysiological mechanism of PD motor impairment; MDS 15th International Congress of Parkinson's Disease and Movement Disorders; June 5-9, 2011;Toronto, ON, Canada (Abstract)

2. L. Pitto, V. Novakovic, A. Basteris, V. Sanguineti. Neural correlates of motor learning and performance in a virtual ball putting task. International Conference on Rehabilitation Robotics (ICORR 2011). June 29-July 1, 2011; Zurich, Switzerland.

3. V. Squeri, A. Basteris, V. Sanguineti. Adaptive regulation of assistance 'as needed' in robot-assisted motor skill learning and neurorehabilitation. International Conference on Rehabilitation Robotics (ICORR 2011). June 29-July 1, 2011; Zurich, Switzerland.

4. A. Basteris, A. De Luca, V. Sanguineti, C. Solaro, M. Mueller, I. Carpinella, D. Cattaneo, R. Bertoni, M. Ferrarin. A tailored exercise of manipulation of virtual tools to treat upper limb impairment in Multiple Sclerosis. International Conference on Rehabilitation Robotics (ICORR 2011). June 29-July 1, 2011; Zurich, Switzerland.

5. A. Basteris, V. Sanguineti. Toward 'optimal' schemes of robot assistance to facilitate motor skill learning, 33rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'11), August 30 - September 3, 2011; Boston, MA, USA.

6. A. Ramos Murguialday, E. Soares, D. Broetz, A. Caria, S. Soekadar, N. Birbaumer; Haptic Brain Computer Interface in Paralyzed Chronic Stroke Patients. Society of Neuroscience 2011; Nov. 12-18; Washington DC, USA. (Abstract)

7. E. Garcia Cossio, A. Ramos Murguialday, E. Soares, N. Birbaumer; Analysis of muscle synergies of EMG in post-stroke patients: paretic and non-paretic hand. Society of Neuroscience 2011; Nov. 12-18; Washington DC, USA. (Abstract)

8. Lüttgen, J. & Heuer, H.: Robot-assisted learning of motor timing. 53. Tagung experimentell arbeitender Psychologen, Halle(Saale) 2011

9. Rapp, K. & Heuer, H.: Auswirkung von mechanischer Unterstützung auf das Lernen visumotorischer Transformationen. 53. Tagung experimentell arbeitender Psychologen, Halle(Saale) 2011

10. W. Cho, C. Vidaurre, U. Hoffmann, N. Birbaumer, A. Ramos; Afferent and Efferent Activity Control in the design of Brain Computer Interfaces for Motor Rehabilitation. Engineering in Medicine and Biology Society (EMBC) Proceedings, 2011 Annual International Conference of the IEEE 2011.

2.4 Patents

1 Masia L., Sandini G. “ A DEVICE FOR MEASURING PLANAR STIFFNESS OF A SAMPLE MATERIAL” , Filing Date 03.06.2011, Application number TO2011A000482, (Patent Pending)

Section 3 Exploitable knowledge and its use

The expected exploitable results are given in the Table 1 below. IPR issues (background/pre-existing and foreground information) are reported in the two matrices below (matrices 1 & 2). The exploitation claims of the partners are indicated in matrix 3.

Table 1 – Overview table on exploitable knowledge

Result no.	*Exploitable Results*	*Exploitable Result Manager*	*Partners Involved*	*Relevant WPs*	*Relevant Deliverables*
1	Development of the environment for robot-assisted neuro-rehabilitation and motor skill learning applications (new technology)	IIT	IIT, AAU, FSM	WP2	D2.1, D3.1, D2.2, D2.3
2	Wrist device	IIT	IIT	WP2	D2.1
3	Stiffness device	IIT	IIT	WP2	D2.1, D2.2
4	New control method for the haptic interface during gaming	AAU	AAU, IIT	WP1, WP3, WP4	
5	Wii-interface for the motivational boost of the training assisted by a robot	AAU	AAU, IIT	WP1, WP3, WP4	
6	General method for adaptive regulation of task parameters to maintain a target level of performance in a motor skill learning or rehabilitation exercise	IIT	IIT	WP2	D2.2
7	Method for intermanual transfer of handwriting skills	IIT	IIT	WP6	D6.1
8	Multidevice- Robot-aided Rehabilitation architecture with Progressive Task Regulation Algorithm	FSM	FSM, IIT	WP2, WP7	D7.2
9	Online sensorimotor rhythm classification for haptic-BCI control	EKU	EKU, IIT	WP5	D5.1, D5.3

3.1 Characterisation of each Exploitable Result

Exploitable result n° 1: **Development environment for robot-assisted neuro-rehabilitation and motor skill learning applications**

Describe the innovation content of result	Open-source, device-independent, multi-robot software platform that exploits the functionalities of H3DAPI – an existing API for visuo-haptic rendering - for the development of robot-assisted motor skill learning and rehabilitation applications ('the HUMOUR system')
Who will be the customer?	Developers of motor skill learning and rehabilitation applications (research and rehab centers)
What benefit will it bring to the customers?	Will provide a common environment for different robot platforms, thus allowing cross-platform exchange of applications and promoting standardization of exercise protocols. Will support multiple devices, thus allowing robot-assisted uni- and bi-manual training and robot-mediated physical interaction between humans
When is the expected date of achievement in the project (Mth/yr)?	Initial version (Basic HUMOUR system) released in mid-2010. Additional functionalities being added until the end of the project (Final HUMOUR system, expected December 2011)
When is the time to market (Mth/yr)?	Public release with full documentation and support at end of project (December 2011)
What are the costs to be incurred after the project and before exploitation?	N/A
What is the approximate price range of this result / price of licenses?	To be determined
What is the market size in M€ for this result and relevant trend?	N/A
How this result will rank against competing products in terms of price / performance?	The system currently supports a variety of existing robot devices, all with proprietary software environments. However, no multi-device, multi-platform software environments specifically designed for robot-assisted motor skill learning and rehabilitation exercises are currently available.
Who are the competitors for this result?	All proprietary software are potential competitors, but only for specific applications

How fast and in what ways will the competition respond to this result?	N/A
Who are the partners involved in the result?	IIT, FSM, AAU
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	SenseGraphics (developers of H3DAPI)
Have you protected or will you protect this result? How? When?	H3DAPI is open-source and distributed under GPL. We plan to do the same. Individual applications may be provided as executables or byte-coded Python scripts

Exploitable Result n° 2: **Wrist device**

Describe the innovation content of result	The system is a 3 degree of freedom robotic manipulator able to move and train human wrist.
Who will be the customer?	Research institutes and Industries working in Robotics, Clinical Rehabilitation, Haptic Technology and Remote Sensing.
What benefit will it bring to the customers?	The system allows to interact with virtual objects in a virtual reality environment by feeding back programmable force control
When is the expected date of achievement in the project (Mth/yr)?	Already developed in prototype version and published papers on international conferences and journals
When is the time to market (Mth/yr)?	January 2012
What are the costs to be incurred after the project and before exploitation?	Refinement of the ergonomy, standardization according CE requirements: 50,000 Euros
What is the approximate price range of this result / price of licenses?	25,000 Euros
What is the market size in M€ for this result and relevant trend?	The trend of new haptic system is spread out over different application. Research, remote robotics,
How this result will rank against competing products in terms of price / performance?	In terms of price the system can be compared with competitors from other companies.
Who are the competitors for this result?	Interactive Motion Technology, Moog, Hocoma, Sensable, ForceDimension, BKin Technology
Who are the partners involved in the result?	IIT
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	To be determined.
Have you protected or will you protect this result? How? When?	Not protected

Exploitable Result n° 3: **Stiffness Device**

Describe the innovation content of result	The system consists in a rotary mechanism able to generate radial perturbation and consequently measure the restoring force of the material to which is mounted
Who will be the customer?	Research institutes and Industries working in Robotics, Clinical Rehabilitation and Haptic Technology and Remote Sensing. The market of mechanical measurement & industrial instrumentation.
What benefit will it bring to the customers?	The system is the first in its category able to accurately estimate the mechanical impedance in a multidimensional way.
When is the expected date of achievement in the project (Mth/yr)?	Already developed in prototype version
When is the time to market (Mth/yr)?	January 2012
What are the costs to be incurred after the project and before exploitation?	10,000 Euros
What is the approximate price range of this result / price of licences?	15,000 Euros
What is the market size in M€ for this result and relevant trend?	Market size is potentially wide and encompasses different disciplines. Since the system is general purpose the interested field may be the industrial one for characterization of materials.
How this result will rank against competing products in terms of price / performance?	At present no competing products are present on market and it may constitute a real improvement and novelty on market
Who are the competitors for this result?	ATI industrial force sensor, Futek, TekScan, JR3, Honeywell
How fast and in what ways will the competition respond to this result?	The market may respond within 6 months
Who are the partners involved in the result?	IIT
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	To be determined; the system has not yet be shown
Have you protected or will you protect this result? How? When?	Patent pending 03.06.2011 n. TO2011A000482

Exploitable Result n° 4: New control method for the haptic interface during gaming

Describe the innovation content of result	New control based on the probalistic tube action representation
Who will be the customer?	Rehabilitation institutions
What benefit will it bring to the customers?	Improved training sessions leading to the improved outcome of the rehabilitation of stroke patients.
When is the expected date of achievement in the project (Mth/yr)?	24
When is the time to market (Mth/yr)?	3 years
What are the costs to be incurred after the project and before exploitation?	150 K
What is the approximate price range of this result / price of licences?	2 K
What is the market size in M€ for this result and relevant trend?	1 M
How this result will rank against competing products in terms of price / performance?	Probably better
Who are the competitors for this result?	Hocoma, Motion Control, Siemens, Rehastim
How fast and in what ways will the competition respond to this result?	Similar devices will reach the market within 1 year
Who are the partners involved in the result?	IIT, AAU
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	Tecnalia, Belgrade, Serbia
Have you protected or will you protect this result? How? When?	Public domain, Publications

Exploitable Result n° 5: Wii-interface for the motivational boost of the training assisted by a robot

Describe the innovation content of result	An electromechanical device which allows the transformation of movement characteristic for humans with disability into the movements that are used for control of the Wii game.
Who will be the customer?	Manufacturers of rehabilitation robots
What benefit will it bring to the customers?	Increased application area for the rehabilitation robots
When is the expected date of achievement in the project (Mth/yr)?	December 2011
When is the time to market (Mth/yr)?	1 Year
What are the costs to be incurred after the project and before exploitation?	70 k€
What is the approximate price range of this result / price of licences?	1 k€
What is the market size in M€ for this result and relevant trend?	1 M€
How this result will rank against competing products in terms of price / performance?	There are no other products by our best knowledge
Who are the competitors for this result?	None
How fast and in what ways will the competition respond to this result?	Immediately
Who are the partners involved in the result?	IIT, AAU
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	Unknown
Have you protected or will you protect this result? How? When?	Small patent

Exploitable Result n° 6: **General method for adaptive regulation of task parameters to maintain a target level of performance in a motor skill learning or rehabilitation exercise**

Describe the innovation content of result	The method allows to automatically adjust task parameters (e.g., task difficulty or degree of robot assistance) in a VR- or robot-based exercise protocol, so that task performance is maintained at a desired, target level. This facilitates subjects' involvement, thus maximizing the learning/recovery speed. The technique is based on a Bayesian approach, and an important feature is that it does not require an accurate knowledge of the initial skill and/or impairment level and the dynamics of the learning and/or recovery process. The method is currently implemented as a Python class hierarchy that can be used standalone or in conjunction with the HUMOUR system (Result n° 1)
Who will be the customer?	HUMOUR consortium
What benefit will it bring to the customers?	The method will be used to develop marketable applications in which the training exercises are highly personalized to individual impairments and must adapt with the progress of learning and/or recovery, not necessarily based on robots.
When is the expected date of achievement in the project (Mth/yr)?	The final version will be available and released in December 2011.
When is the time to market (Mth/yr)?	0
What are the costs to be incurred after the project and before exploitation?	N/A
What is the approximate price range of this result / price of licences?	TBD
What is the market size in M€ for this result and relevant trend?	N/A
How this result will rank against competing products in terms of price / performance?	TBD
Who are the competitors for this result?	Many research groups develop technique to regulate task parameters. This is often achieved through linear control models (Krebs et al., 2003, Riener et al., 2005). These methods are based

	on hypothesis about the dynamics of the learning and relearning process that is still not completely understood. The most similar method is the RGS (Rehabilitation Gaming System; Cameirão et al., 2010) based on a Personalized Training Module (PTM) that adjust task difficulty according to previous performance. Some differences are detectable between the two methods: 1. The relationship between the performance and the task difficulty is linear in our case while is non linear in their technique 2. They use a linear regression to set the task difficulty while we use a probability density function to fit data. 3. We adjust task difficulty trial by trial.
How fast and in what ways will the competition respond to this result?	N/A
Who are the partners involved in the result?	IIT
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	To be determined
Have you protected or will you protect this result? How? When?	No. Specific applications will be distributed as executables or byte-coded Python scripts

Exploitable Result n° 7: **Method for intermanual transfer of handwriting skills**

Describe the innovation content of result	People may need to transfer handwriting skills to their non-dominant hand as a consequence of stroke or amputation. We demonstrated that training in a virtual environment under physical assistance may facilitate this transfer. This may also apply to the acquisition of handwriting skills in children.
Who will be the customer?	Occupational therapists in rehab centers
What benefit will it bring to the customers?	Will speed up intermanual transfer, which requires months with standard occupational therapy protocols Will work with a variety of robot trainers, which may be already available to customers
When is the expected date of achievement in the project (Mth/yr)?	Method validated with healthy subjects and manipulandum-type robot. Journal paper currently under review
When is the time to market (Mth/yr)?	TBD
What are the costs to be incurred after the project and before exploitation?	Will need to develop a dedicated set-up with a robot-actuated pen
What is the approximate price range of this result / price of licenses?	<5 k€
What is the market size in M€ for this result and relevant trend?	Unknown
How this result will rank against competing products in terms of price / performance?	Unknown
Who are the competitors for this result?	There are several prototypes around. The most advanced device is MyScrivener, a robot-based device developed by S. Palsbo at George Mason University
How fast and in what ways will the competition respond to this result?	Unknown
Who are the partners involved in the result?	IIT
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	TBD
Have you protected or will you protect this result? How? When?	Not yet

Exploitable Result n° 8: **Multidevice- Robot-aided Rehabilitation architecture with Progressive Task Regulation Algorithm**

Describe the innovation content of result	Multidevice- Robot-aided Rehabilitation architecture with Progressive Task Regulation Algorithm
Who will be the customer?	Rehabilitation Institutions
What benefit will it bring to the customers?	Support of different robotic devices with the same user interface and improved training for patients with different level of impairment.
When is the expected date of achievement in the project (Mth/yr)?	36
When is the time to market (Mth/yr)?	3 years
What are the costs to be incurred after the project and before exploitation?	200 k
What is the approximate price range of this result / price of licences?	15 k
What is the market size in M€ for this result and relevant trend?	1 M
How this result will rank against competing products in terms of price / performance?	Probably better
Who are the competitors for this result?	Hocoma, Rehastim
How fast and in what ways will the competition respond to this result?	Similar devices could reach the market within 1.5 years
Who are the partners involved in the result?	IIT, FSM
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	Force Dimension, Celin
Have you protected or will you protect this result? How? When?	Public domain, Publications

Exploitable Result n° 9: Online sensorimotor rhythm classification for haptic-BCI control

Describe the innovation content of result	Algorithm to control an on-line haptic BCI closing the loop non-invasively between brain and muscles.
Who will be the customer?	Rehabilitation Institutions
What benefit will it bring to the customers?	A contingent proprioceptive feedback linking brain and movement in paralyzed patients
When is the expected date of achievement in the project (Mth/yr)?	36
When is the time to market (Mth/yr)?	TBD
What are the costs to be incurred after the project and before exploitation?	250K
What is the approximate price range of this result / price of licences?	12K
What is the market size in M€ for this result and relevant trend?	1M
How this result will rank against competing products in terms of price / performance?	There is no product in the market for completely paralysis rehabilitation
Who are the competitors for this result?	Other Universities, HOCOMA, OttoBock
How fast and in what ways will the competition respond to this result?	They can reproduce results or try to buy the IP
Who are the partners involved in the result?	EKU
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	Tecnalia
Have you protected or will you protect this result? How? When?	Publications

Exploitable Result n° 10: Online functional NIRS-BCI

Describe the innovation content of result	Online functional NIRS-BCI system for self-regulation of local brain activity.
Who will be the customer?	Rehabilitation Institutions
What benefit will it bring to the customers?	A portable and flexible system allowing users to learn to control and modulate specific brain activity. Patients may benefit as previous studies based on real-time fMRI demonstrated that volitional control of hemodynamic activity leads to brain reorganization.
When is the expected date of achievement in the project (Mth/yr)?	36
When is the time to market (Mth/yr)?	TBD
What are the costs to be incurred after the project and before exploitation?	250K
What is the approximate price range of this result / price of licences?	12K
What is the market size in M€ for this result and relevant trend?	1M
How this result will rank against competing products in terms of price / performance?	There is no such a product in the market to be used for patients with motor disabilities
Who are the competitors for this result?	Other Universities
How fast and in what ways will the competition respond to this result?	They can reproduce results
Who are the partners involved in the result?	EKU
Who are the industrial partners interested in the result (partners, sponsors, etc…)?	Tecnalia
Have you protected or will you protect this result? How? When?	Publications

3.2 IPR'S on background information

Information, excluding foreground information, brought to the project from existing knowledge, owned or controlled by project partners in the same or related fields of the work carried out in the research project.

RESULTS/ **PARTNERS**	1	2	3	4	5	6	7	8	9
IIT	**B**	**B**	**B**	**B**	**B**	**B**			
AAU	**B**			**B**	**B**				
FSM	**B**				**B**			**B**	
EKU				**B**	**B**				**B**
IfADO				**B**		**B**			
Imperial	**B**			**B**	**B**	**B**			

3.3 IPR's on foreground information

Information including all kind of exploitable results generated by the project partners or 3rd parties working for them in the implementation of the research project

RESULTS/ **PARTNERS**	1	2	3	4	5	6	7	8	9
IIT	**F**	**F**	**F**			**F**	**F**		
AAU				**F**	**F**				
FSM	**F**							**F**	
EKU	**F**								**F**
IfADO	**F**					**F**			
Imperial	**F**					**F**			

3.4 Exploitation claims

The intention of the partners to exploit the results by making them and selling them (**M**); by using them internally to make something else for sale (**U**); to license them to 3rd parties (**L**); to provide services such as consultancy, etc…(**O**).

RESULTS/ PARTNERS	1	2	3	4	5	6	7	8	9
IIT	M,U	U,L	U,L	U, L	U, L	U	U,L		
AAU				M,U,L,O	M,U,L,O				
FSM								U,L	
EKU									U,L
IfADO									
Imperial									

3.5 IPRs and exploitation claims

(the sum of the three previous matrices)

RESULTS/ PARTNERS	1	2	3	4	5	6	7	8	9
IIT	B,F,M,U	B,F,U,L	B,F,U,L	B,F,U,L	B,F,U,L	B,F,U	B,F,U, L		
AAU	B			B,F,M,U,L,O	B,F,U,L,O				
FSM	B, F				B			B,F,U,L	
EKU	F			B					B,F,U,L
IfADO	F			B	B	B,F			
Imperial	B,			B	B	B,F			