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PRESENTATION AND POSTER ABSTRACTS

(NOTE: Full papers are available for download at the IGS website)

CHAIR: Jose L. Contreras-Vidal, University of Maryland, USA
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Monday June 13th

PLENARY TALK (SPONSORED BY G.TEC)
Mikhail Lebedev, Duke University Center for Neuroengineering
"Brain-Machine Interfaces: From Locomotion to Fine Hand Movements"

Recent progress in brain-machine interfaces (BMIs) has been driven by the expectation that neural prosthetics based on BMI technology will provide a breakthrough treatment for paralysis caused by neural injury and disease. In my talk, I will review recent work of the Nicolelis primate laboratory aimed at eventually bringing BMIs to clinical practice. We implant rhesus monkeys with multielectrode arrays in multiple cortical areas. Neuronal ensemble activity recorded by these arrays is processed by decoding algorithms to extract various motor parameters. We have explored BMIs that reproduce a rich repertoire of motor activities: from bipedal locomotion to reaching movements and motor timing. Importantly, accurate BMI control and extraction of many degrees of freedom simultaneously is possible when large neuronal ensembles are recorded. Moreover, we have added a somatosensory feedback loop to our BMI for reaching. This feedback was based on intracortical microstimulation of the primary somatosensory cortex and acted as an artificial touch during monkey reaches to virtual objects, performed under BMI control. Based on these results, we envision that sensorized neural prosthetic devices will be developed in the future to restore a variety of functions to disabled – from the ability to walk to handwriting.

Mikhail Lebedev received his undergraduate degree in Physics from Moscow Institute of Physics and Technology and his PhD degree in Neurobiology in University of Tennessee, Memphis. He conducted research on motor control and neurophysiology at the Institute for Information Transmission Problems, Moscow, University of Tennessee, Memphis, La Scuola Internazionale Superiore di Studi Avanzati, Trieste and National Institute of Mental Health, Bethesda. He is currently a Senior Research Scientist at Duke University Center for Neuroengineering. Research interests include system neurosciences, primate motor control and cognition and brain-machine interfaces.

CONTRIBUTED SESSION (Chair: Angelo Marcelli): MOVEMENT NEUROSCIENCE

Improvements of Movement Performance as Result of Bilateral Transfer of Learning. *Zhujun PAN & Arend. W. A. VAN GEMMERT,* Fine Motor Control and Learning Laboratory
Department of Kinesiology, Louisiana State University, Baton Rouge, LA 70803
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Abstract. In our previous study, it was shown that the direction of asymmetry for bilateral transfer is measurement dependent. This study aimed to gain more insight into the relationship among the measures of movement duration, trajectory length, initial direction, duration of corrective movements, and movement smoothness. Subjects were required to make point-to-point drawing movements while adapting to a visual distortion resulting in visual feedback with a 45° rotation and 2 gain of pen movements. We examined performance of the non-dominant hand after practice of the dominant hand of half of the subjects, while performance of the dominant hand was examined after practice with the non-dominant hand of the other half of the subjects. To assess the relationships between performance improvements, correlations of change rates among the measures were analyzed. The results showed that the change of movement time is associated with movement smoothness in RR (right hand training, right hand testing) condition, with duration of corrective movement in LL (left hand training, left hand testing) condition, with both movement smoothness and duration of corrective movement in RL (right hand training, left hand testing) condition, and is not associated with any other measures in LR (left hand training, right hand testing) condition. The results suggest that there are different patterns of transfer at kinematic level for the four learning conditions. Furthermore, the occurrence of the asymmetry of bilateral transfer may be caused by the fact that the untrained non-dominant hand can use more information than the untrained dominant hand from the trained opposite hand to improve performance.

Generalization of Dynamic Adaptation between Bilateral and Unilateral Movement Conditions. Jinsung WANG**,** *Department of Human Movement Sciences, University of Wisconsin 53201, Milwaukee, WI, USA* {wang34@uwm.edu}

Abstract. The efficacy of bilateral training for improving unilateral performance has recently been questioned by a study which demonstrated that bilateral adaptation to a novel dynamic condition during targeted reaching movement facilitated subsequent unilateral performance, but only to a limited extent. However, findings from another study indicated nearly complete transfer of novel visuomotor adaptation from a bilateral to a unilateral condition. The observed discrepancy may be attributed to the fact that the two studies examined the extent of generalization in different ways. Thus, the present study attempted to investigate the extent of generalization of novel dynamic adaptation between bilateral and unilateral conditions again, but by employing the experimental paradigm used in the latter study. The task employed in the present study was to make targeted reaching movement under a novel force field condition, with either one arm or both arms simultaneously. Results indicated poor performance with either arm during the bilateral session, which indicated some bilateral interference effects. However, the unilateral performance following bilateral training was superb from the beginning of the session, indicating a substantial amount of transfer from bilateral to unilateral conditions. These findings confirm that bilateral training is an effective method for improving unilateral performance.

Characterizing synergies of grasping in the human hand. Harshavardhan A. AGASHE and José L. CONTRERAS-VIDAL, *Graduate Program in Neuroscience and Cognitive Science, Department of Kinesiology, and Fischell Department of Bioengineering, University of Maryland, College Park, MD 20740 USA* {agashe@umd.edu, pepeum@umd.edu}

Abstract. The ability of human hands to manipulate objects with such fine control stems from the many degrees of freedom afforded by the biomechanics of the hand. Previous studies show that movement synergies described by a few principal components may be the solution adopted by the nervous system to simplify the control problem. In this study we assess the consistency of synergies across sessions and individuals, and characterize the evolution of the consistent components in time. Twenty three joint angles were recorded in five subjects while they reached and grasped five objects. Cluster analysis showed that only the first 3 principal components were consistent within and across subjects. The first synergy encoded the opening and closing movement of the four fingers. The second synergy accounted for the finger and thumb abductions and controlled the lateral spreading of the hand. The third synergy was found to control the thumb rotation.

CONTRIBUTED SESSION (Chair: RéjeanPlamondon): BRAIN-MIND-MACHINES I

On the development of a simple EOG-based mouse with BCI technology applying Empirical Mode Decomposition and DWT. Gerardo ROSAS-CHOLULA, Juan Manuel RAMÍREZ-CORTES, Jorge ESCAMILLA-AMBROSIO, Vicente ALARCÓN-AQUINO**,** National Institute of Astrophysics, Optics and Electronics. Department of Electronics**,** Calle Luis Enrique Erro No. 1, Tonantzintla, Puebla, 72760, Mexico and University of the Americas, Puebla. Department of Electronics and Computer Science Exhda. Sta. Catarina Martir, Cholula, Puebla, 72720, Mexico {grosas, jmram,jescami}@inaoep.mx, {vicente.alarcon@udlap.mx}

Abstract. This paper presents an on-going project on the development of a simple cursor control emulating the typical operations of a computer-mouse, using electro-oculography signals (EOG) obtained indirectly through a commercial 16-electrodes wireless headset originally used to acquired EEG signals. The cursor position is controlled using information from a gyroscope included in the headset. The clicks are generated through the user's blinking with an adequate detection procedure based on spectral analysis. Empirical Mode Decomposition (EMD) technique is explored as a simple and quick computational tool, yet effective, aimed to the pulse detection in a noisy signal, as well as a validation method to distinguish between natural blinking and blinks for control. EMD is compared with a spectral analysis based on the Discrete Wavelet Transform (DWT). The experimental setup, some obtained results, and a comparison among the two used spectral analysis, are presented.

Decoding Finger Movements from Brain Activity Acquired via Scalp Electroencephalography. Andrew PAEK, Harshavardhan AGASHE, Kimberly KONTSON, and Jose L. CONTRERAS-VIDAL, *Fischell Department of Bioengineering, Neuroscience and Cognitive Science Graduate Program,* and *Department of Kinesiology, University of Maryland College Park 20742, USA* {apaek, agashe, kkontson, pepeum}@umd.edu,

Abstract. In this study, we investigated how well finger movements can be decoded from electroencephalography (EEG) signals. 23 hand joint angles were measured simultaneously with 64-channel EEG while subjects performed a repetitive finger tapping task. A linear decoder was used to predict continuous index finger angular velocities from EEG signals. A genetic algorithm was used to select EEG channels across temporal lags between the EEG and kinematics recordings, which optimized decoding accuracies. To evaluate the accuracy of the decoder, the Pearson's correlation coefficient (r) between the observed and predicted trajectories was calculated in a 10-fold cross-validation scheme. Our results (median r = .403, maximum = .704), compare favorably with previous studies that used electrocorticography (ECoG) to decode finger movements. The decoder used in this study can be used for future brain machine interfaces, where individuals can control peripheral devices through EEG signals.

Online Mode Detection for Pen-Enabled Multi-Touch Interfaces. Marcus LIWICKI, Markus WEBER, and Andreas DENGEL, *German Research Center for Artificial Intelligence (DFKI) Trippstadter Str. 122, 67663 Kaiserslautern* and *Knowledge-Based Systems Group, Department of Computer Science, University of Kaiserslautern, P.O. Box 3049, 67653 Kaiserslautern , Germany* {*firstname.lastname*}@*dfki.de*

Abstract. In this paper we describe a system which allows for intuitive pen input for human-machine-interaction on multi-touch surfaces. The system automatically analyzes the handwritten strokes and detects if they correspond to handwriting or to graphics or symbols. We propose an architecture which integrates this online mode detection system into a software development kit (SDK) to ease the design of pen-based applications. This novel toolkit allows for automated ink interpretation including handwriting recognition and shape detection. We have evaluated our system on a set of 1,600 handwritten words and symbols and integrated this system into a running demonstration prototype.

CONTRIBUTED SESSION (Chair: Arend Van Gemmert): COMPUTATIONAL MODELS

NeuroHand: A neural algorithm for solving the inverse cinematic redundancy. Marina BELTRÁN-BLANCO, Javier MOLINA-VILAPLANA, José Luis MUÑOZ-LOZANO, Juan LÓPEZ-CORONADO, *Automatic and System Engineering Department, Polytechnic University of Cartagena, C/ Doctor Fleming, s/n 30202, Cartagena (Murcia) SPAIN* {Marinabb28@hotmail.com}, {javi.molina, joselu.mlozano, jl.coronado}@upct.es

Abstract. If an anthropomorphic arm has to reach a point in its workspace, many joint configurations are possible. The inverse kinematic redundancy consists on several possible arm joint configurations for reaching the target point with the wrist (open kinematic chain). The humans solve the kinematic redundancy in a natural way learned in childhood. In this paper we describe a learning algorithm for artificial neural networks used to solve the inverse kinematic redundancy in order to make a virtual robotic anthropomorphic arm has a 'human' joint configuration to reach a target point.

From Motor to Trajectory Plan: A Feedback Loop between Unfolding and Segmentation to improve Writing Order Recovery. Rosa SENATORE, Adolfo SANTORO and Angelo MARCELLI, *Natural Computation Lab, DIEII, University of Salerno*, *Via Ponte Don Melillo, 1, 84084, Fisciano(SA), ITALY* {rsenatore, adsantoro, amarcelli}@unisa.it

Abstract. We present a method derived from studies about trajectory planning and motor control for improving the writing order recovered from off-line cursive handwriting. Starting from a static image of an handwritten word, stroke detection is possible only after dynamic information (in terms of writing order) has been reconstructed. Naturally, strokes type and position are influenced by dynamic order retrieval, meaning that each trajectory, built on a particular ordered sequence of points, gives rise to a particular sequence of strokes. A similar process occurs in the brain when a motor task must be accomplished: desired trajectory is retrieved and corresponding movements are selected. Moreover, a proprioceptive feedback loop allows to coordinate and correct movement execution. As learning occurs, movement sequences are organized and modified in order to perform the handwriting task with the minimal metabolic energy expenditure. Exploiting the analogy with these processes, we have introduced a feedback loop between the segmentation and the unfolding step, using strokes obtained from segmentation to validate or invalidate the retrieved dynamics provided by unfolding. The experimental results show an increase in performance of writing order recovery, leading to the conclusion that this

added feedback provides our system the ability to train itself on the basis of errors, emulating learning process that occurs in the brain when a new motor skill is learned.

Experimental Confirmation of the Proportional Effect Hypothesis of the Kinematic Theory of Rapid Movements. Moussa Djioua, Réjean Plamondon and Pierre A Mathieu, *École Polytechnique de Montréal C.P. 6079, Succursale Centre-Ville H3C 3A7, Montréal, CANADA and* Institut de génie biomédical, Université de Montréal. {rejean.plamondon@polymtl.ca; mathieu @igb.umontreal.ca}

Abstract. The Kinematic Theory has been exploited successfully for more than a decade in applications dealing with handwriting processing and in the modeling of the neuromuscular system involved in the production of rapid movements. The main underlying assumption of this theory is that the cumulative time delays of the propagated impulse responses, as recorded at different points along the neuromuscular system, are linked by proportional relationships. The present study aims at verifying this assumption through the recording of surface electromyograms (EMG) from six main muscles of the upper limb activated during rapid handwriting strokes. Using EMG envelopes, proportional regressions were obtained between the cumulative time delays of the activities of those muscles. The high correlation coefficients of these proportionality relationships provide a strong experimental support for the proportionality hypothesis assumed in the Kinematic Theory.

The Coupling of Agonist and Antagonist Commands in Speed/Accuracy Tradeoff
Christian O'Reilly and Réjean Plamondon, *École Polytechnique de Montréal*, *C.P. 6079, Succursale Centre-Ville*, *H3C 3A7, Montréal, CANADA* {christian.oreilly, rejean.plamondon} @polymtl.ca

Abstract. This paper reports results on the coupling between the Delta-Lognormal command parameters sent to the agonist and antagonist neuromuscular groups in movements entailing a speed/accuracy tradeoff. Our study was performed on a large (120 subjects) and varied sample (both gender, wide age range, various health conditions). Results show that the subjects must correlate more tightly the impulse commands sent to both neuromuscular groups in order to achieve good performances as the difficulty of the task increases.

Synthetic Handwritten Gesture Generation Using Sigma-Lognormal Model for Evolving Handwriting Classifiers. Abdullah Almaksour and Eric Anquetil, *INSA de Rennes, FRANCE*, Rejean Plamondon, Christian O'Reilly, *Ecole Polytechnique de Montral, CANADA* {christian.oreilly, rejean.plamondon}@polymtl.ca

Abstract. We show in this paper the importance of using handwriting generation in the context of online and incremental learning of a handwriting classifier. In order to obtain realistic synthetic gestures, we apply controlled deformations on the extracted sigma-lognormal parameters of the real gesture, and we then generate synthetic gestures using the modified parameters. Results show the impact of integrating these synthetic samples generation in our learning algorithm on the classification performance.

Decoding volitional three-dimensional hand movement direction from EEG. Teodoro GARCÍA EGEA [a], Trent BRADBERRY [b], Juan LÓPEZ CORONADO [a] and José L. CONTRERAS-VIDAL [b,c,d], [a] *Automatic and System Department, Polytechnical University of Cartagena*, *Campus Muralla del Mar, Cartagena, SPAIN*, [b] *Departments of Kinesiology &* [c]*Bioengineering, and the* [d]*Neuroscience and Cognitive Science, University of Maryland School of Public Health*, *20742 College Park, USA* {Teodoro.garcia,jlopez}@upct.es, {trentb, pepeum}@umd.edu

Abstract. The feasibility of continuous decoding self-initiated, self-selected hand movements to three-dimensional (3D) spatial targets from scalp electroencephalo-graphy (EEG) using linear decoders has been recently demonstrated (Bradberry, Gentili & Contreras-Vidal, 2010; J. Neurosci. 30(9):3432-7). In this paper, we show that it is possible to train linear classifiers to decode hand movement direction to eight 3D spatial targets, in both planning and movement windows, using only the fluctuations in the amplitude of smoothed signals from high-density scalp EEG. This result supports the design of brain-computer interfaces (BCI) based on non-invasive scalp EEG signals and suggests that the current perception of the limits of EEG as a source signal for BCI applications merits further examination.

CONTRIBUTED SESSION (Chair: Pepe Contreras-Vidal): FORENSIC SCIENCE IN ART

Exploiting Page Layout Features for Scribe Distinction in Medieval Manuscripts. Claudio DE STEFANO [a], Francesco FONTANELLA [a], Marilena MANIACI [b] and Alessandra SCOTTO di FRECA [a], [a] *Dipartimento di Automazione, Elettromagnetismo, Ingegneria dell'informazione e Matematica Industriale, University of Cassino , Via Di Biasio, 43, 04303 Cassino (FR), ITALY,* [b] *Dipartimento di Filologia e Storia, University of Cassino, Via Zamosch, 43, 04303 Cassino (FR), ITALY* {destefano, fontanella, mmaniaci, a.scotto}@unicas.it

Abstract. Palaeography is the study of ancient handwriting, aiming not only at deciphering, reading, and dating historical manuscripts, but also at reconstructing and interpreting the history of writing techniques and styles from the Antiquity to the end of the Middle Ages. Palaeographers are therefore engaged in discovering when a manuscript was written, where it was written and how the writing was technically executed; they are also interested in characterizing features and habits of individual scribes and in distinguishing them from one another. In this framework, the use of digital image processing techniques has received increasing attention in recent years, resulting in a new research field commonly denoted as "digital palaeography". In such a field, a key role is played by both pattern recognition and feature extraction methods, which provide quantitative arguments for supporting expert deductions. In this paper, we present a pattern recognition system which tries to solve a typical palaeographic problem: to distinguish the different scribes who have worked together to the transcription of a single medieval book. In the specific case of a high standardized book typology (the so called Latin "Giant Bibles"), we wished to verify if the extraction of certain specifically devised features, concerning the layout of the page, allowed to obtain satisfactory results. The experiments, performed on a large dataset of digital images from the so called "Avila Bible" – a giant Latin copy of the whole Bible produced during the XII century between Italy and Spain – confirmed the effectiveness of the proposed method.

How age, culture and manual dominance determine directionality in profile-drawings. Annie VINTER and Hana KEBBE**,** *University of Bourgogne, LEAD, CNRS 5022, Pôle 2AFE, Esplanade Erasme, 21000, Dijon, FRANCE* {annie.vinter, hana.kebbe@u-bourgogne.fr}

Abstract. The present experiment aimed at investigating to what extent the orientation of objects in profile drawings was a function of age, culture and manual dominance. French and Syrian right-handed children aged between 6 and 10 years and right-handed adults were asked to produce profile views of faces, vehicles (car and airplane), self-centred objects with a handle (mug and toothbrush), objects-centred tool or object with a handle (jug and hammer) and animals (dog and fish), with their dominant and non-dominant hand. French participants showed a leftward directional bias whereas Syrian individuals displayed a rightward bias. However, no differences between the two cultural groups were observed in the 6-year-olds, who did not present any systematic directional bias in their drawings. Furthermore, regardless of culture,

children did not modify object's directionality in their drawings as a function of hand, whereas the hand effect was strong in adults. Finally, despite their directional bias toward the right, Syrian participants tended to draw the mug, the jug and the toothbrush facing leftward, similarly to the French individuals. These results are discussed in reference to the current literature on this topic.

A forensic handwriting examination of manuscripts attributed to Johann Sebastian and Anna Magdalena Bach. Martin JARVIS (*Charles Darwin University*, Australia), *Charles Darwin University, Darwin, Australia NT 0909* {Martin.Jarvis@cdu.edu.au}

Abstract. Abstract not available.

Tuesday June 14th

PLENARY SESSION: (SPONSORED BY BRAIN VISION LLC)

Marc H. Schieber, Professor of Neurology and of Neurobiology, University of Rochester, and Brain Injury Rehabilitation Unit at Unity Health, Rochester, NY
"Changing Circuits that Control the Fingers: Dissociating Motor Cortex from the Motor"

Abstract. Although the fingers of the human hand have evolved toward independence, attempts at moving a single digit typically include movements of other digits as well, reflecting both biomechanical and neural linkages. In spite of these linkages, the primary motor cortex has evolved to generate dexterous movements. To do so entails remarkable flexibility in how the activity of various cortical neurons combines to individuate movement. We tend to make the simplifying assumptions that the functional role of a given cortical neuron and its effect on a particular muscle's motoneuron pool both remain relatively constant. If so, then the activity of multiple cortical neurons, each weighted by the strength of its effects on each muscle's motoneuron pool, should sum to predict the activity of their common target muscles. In actuality, however, such simple summing of cortical neuron activity accounts for muscle activity only partially. Rather than upper motor neurons controlling fixed synergies of muscles, cortical neurons appear to flexibly recombine in the production of different individuated finger movements. Furthermore, the effect of a given cortical neuron on a particular motoneuron pool may vary depending on the movement being performed. We examined this possibility by rewarding monkeys for discharging the same cortical neuron in combination with different target muscles. During co-activation of a given cortical neuron with various muscles, the amplitude of spike-triggered average effects between the cortical neuron and any given muscle often varied substantially. In some cases, a post-spike effect that indicated a monosynaptic cortico-motoneuronal (CM) connection was clearly present during some epochs, but absent during others. The throughput of CM connections thus appears to be variable. If a CM cell's effect on muscles is variable, then can the function of cortical neurons vary as well? When neuron firing rates are used for closed-loop control of a brain-machine interface, many neurons change their preferred direction, limb movements diminish, and eventually muscle contractions stop. Cortical neurons then continue to discharge in dissociation from the body movements they previously seemed to control. We therefore are beginning to examine factors that determine whether motor cortex neurons can be combined into small ensembles, dissociated from finger movements, and used to drive a cursor in one-dimension. Preliminary results using unselected neurons recorded initially during a center-out task show that better performance during cursor control can be obtained with increasing numbers of neurons (up to 4), but that neither the directional tuning of the individual neurons in an ensemble or the distance between them affects performance substantially. These observations suggest that motor cortex neurons are flexible enough to quickly re-combine and function in new roles.

Dr. Marc H. Schieber received his A.B. in 1974, and M.D./Ph.D. in 1982, from Washington University in St. Louis. He currently is Professor of Neurology and of Neurobiology at the University of Rochester, and Attending Neurologist on the Brain Injury Rehabilitation Unit at Unity Health, Rochester, NY. His research focuses on how the nervous system controls muscles to perform dexterous finger movements. Dr. Schieber is a member of the Society for Neural Control of Movement and the Society for Neuroscience. He has received an NINDS Javits Investigator Merit Award and has served as Chair of the NIH Sensorimotor Integration Study Section.

SPECIAL SESSION (Chair: Angelo Marcelli): BRAIN-MACHINE INTERFACES (BMI) FOR DEXTEROUS MOVEMENT CONTROL

Providing sensory feedback through intracortical microstimulation for upper limb neuroprostheses. S.J. Bensmaia, Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL, USA.

Tactile sensation is critical for effective object manipulation, but current prosthetic upper limbs make no provision for delivering haptic feedback to the user. For individuals who require use of prosthetic limbs, this lack of feedback transforms a mundane task into one that requires extreme concentration and effort. Although vibrotactile motors and sensory substitution devices can be used to convey gross sensations, a direct neural interface is required to provide detailed and intuitive sensory feedback. In light of this, the new generation of neuroprostheses will enable electrical stimulation of sensory neurons. Accordingly, we develop approaches to use electrical stimulation of neurons in areas 3b and 1 of S1 to convey tactile information required for basic object manipulation, namely information about contact location (where is the object touching the skin?) and contact force (how much force is it exerting on the skin?). To this end, we train non-human primates to perform location-discrimination and force-discrimination tasks. In the location discrimination task, two indentations are delivered to different locations on the hand, and the animal judges whether the second stimulus was to the right or to the left of the first. In the intensity discrimination task, two indentations are delivered to the same location on the hand, and the animal judges which of the two stimuli exerted the greater force on the skin. Once the animals are trained, we implant multielectrode arrays in the hand representations within areas 3b (floating microelectrode arrays, Microprobes for Life Sciences, Inc.) and area 1 (Utah electrode arrays, Blackrock Microsystems, Inc.). We then resume the behavioral experiments but replace a subset of mechanical stimuli with electrical stimuli strategically applied to populations of somatosensory neurons. We can then determine how the projected locations and perceived magnitudes of ICMS-elicited percepts relate to those of mechanical indentations. We find that we can elicit percepts of systematically increasing magnitude by increasing the amplitude of electrical pulse trains. Furthermore, electrically induced percepts are highly localized, particularly when electrical stimulation is applied to area 3b. We examine the degree to which electrical stimulation of different neural populations across the cortical sheet elicits different behavioral responses from the animals and relate these behavioral differences to properties of the stimulated populations.

Sliman Bensmaia is an assistant professor of Organismal Biology and Anatomy at the University of Chicago. He received his Ph.D. from the University of North Carolina, at Chapel Hill, under the tutelage of Dr. Mark Hollins, then worked as a postdoctoral fellow at Johns Hopkins University under the mentorship of Dr. Kenneth Johnson. His work focuses on neural coding and the neural basis of perception in the primate somatosensory system.

Sensorimotor integration for the control of grasp kinematics and kinetics: potential applications to BMI. Marco Santello**,** School of Biological and Health Systems Engineering, Arizona State University, USA

Abstract: Grasping and manipulation rely on accurate spatial and temporal coordination of the digits. This coordination is mediated by the integration of sensory feedback from several modalities. The role of sensory feedback is two-fold: (1) to implement corrections online as the movement is being performed, and (2) to update internal models that can be used to predict the consequences of planned actions. The interplay between "reactive" and "anticipatory" control is particularly has been extensively studied in human grasp and manipulation tasks. However, very little is known about how humans learn to control digit positions and forces through consecutive manipulations, mainly because grasp studies have often constrained digit placement to fixed locations, e.g., on force sensors. Allowing subjects the choice of digit placement enables them to explore a wider range of relations between digit forces and positions. At the same time, the removal of digit placement constraints might result in significant trial-to-trial variability of digit position. Consequently, reliance on sensorimotor memories of digit forces from previous trials for anticipatory grasp control might not be sufficient to attain a consistent performance. This is because the points of force application in the current trial might be very different from those used in previous trials, thus requiring a digit force distribution that has not been previously experienced. I will review a series of recent studies that have examined the problem of digit position/force coordination using tasks that allow, or interfere with, learning of object manipulation and probe learning transfer to manipulations of the same object with different properties or performed using a different grip configuration. The theoretical framework that is currently emerging indicates that anticipatory control of object manipulation is learned through integration of sensorimotor memories with online feedback about digit forces and positions. Specifically, subjects can flexibly compensate for trial-to-trial variability in digit position by force modulation, and can switch grip type by successfully adapting the coordination between digit forces and position within a single trial. These observations provide insights into the design of control algorithms and hardware of brain-machine interfaces (BMI) for the control of hand prostheses. Specifically, BMI research on hand control could benefit from observations of how grasp kinematics and kinetics are seamlessly integrated in human grasp planning and execution, and in particular on the role of online vision and tactile sensing for digit force coordination. Therefore, to improve the versatility of BMI for hand control, grasp kinematics and kinetics will have to be studied as belonging to a continuum, rather than as discrete domains. I will conclude my talk with open questions and directions for future research on the neural mechanisms underlying learning of dexterous manipulation and its applications to BMI.

Marco Santello received the Bachelor in Kinesiology from the University of L'Aquila, Italy, in 1990 and a Doctoral degree in Exercise Sciences from the Univ. of Birmingham (UK) in 1995. After a post-doctoral fellowship at the Department of Physiology (now Neuroscience) at the Univ. of Minnesota, he joined the Department of Kinesiology at Arizona State University (ASU) (1999-2010). He is currently Professor of Bioengineering at the School of Biological and Health Systems Engineering and Director of the Neural Control of Movement Laboratory at ASU. Dr. Santello has received research awards from the National Institutes of Health, the National Science Foundation, the Whitaker Foundation, ASU/Mayo Clinic. His main research interests are motor control, learning, and biomechanics of object grasping and manipulation, neural control of hand muscles, multisensory integration, and robotics. He is a member of the Society for Neuroscience and the Society of Neural Control of Movement.

What of Brain-Machine Interfaces (BMI) can be left to non-cortical and peripheral processes?
Francisco Valero-Cuevas, Brain-Body Dynamics Laboratory**,** Professor of Biomedical Engineering**,** Biokinesiology and Physical Therapy**.** By courtesy Professor of Computer Science & Aerospace and Mechanical Engineering**,** The University of Southern California **{**http://bbdl.usc.edu/}

While it is clear that brain-body co-evolutionary processes gave rise to the current structure and function of the neuro-musculo-skeletal system, we do not know if we are dexterous because or in

spite of our subcortical or anatomical structures. I provide two examples of how the structure of the body can be considered to enable or facilitate control of the limbs. The first is the role limb posture plays in defining the ease with which we can produce motion or force in specific directions. The other is the way in which the tendon network of the fingers can change the realm of mechanical outputs. However, I also present an example of how dexterous manipulation engages large, broadly distributed and context-sensitive networks of brain activity. These examples serve to show how considering the co-evolution of brain and body is essential to understand function, dysfunction, rehabilitation, and approaches to BMI.

In 1991, Dr. Valero-Cuevas joined the doctoral program in the Design Division of the Mechanical Engineering Department at Stanford University. I worked with Dr. Felix Zajac developing a realistic biomechanical model of the human digits. This research, done at the Rehabilitation R & D Center in Palo Alto, focused on predicting optimal coordination patterns of finger musculature during static force production. In 1997, he joined the core faculty of the Biomechanical Engineering Division at Stanford University as a Research Associate and Lecturer. His research then focused on developing experimental methods to optimize the surgical restoration of hand function following spinal cord injury and peripheral nerve injuries. In 1999, he joined the faculty of the Sibley School of Mechanical and Aerospace Engineering at Cornell University as an Assistant Professor. In 2007, he joined the faculty at the Department of Biomedical Engineering and the Division of Biokinesiology & Physical Therapy at the University of Southern California as an Assistant Professor. Since 2011, he is a Full Professor in the Department of Biomedical Engineering.

Do cortical gamma responses reflect cognitive-motor information encoding of fine motor tasks?
Nathan CRONE, The Johns Hopkins University, Baltimore, MD, USA.

Abstract. Intracranial EEG (iEEG) recordings have long been used to help guide epilepsy surgery when noninvasive studies cannot adequately localize the seizure focus. Using either depth electrodes or cortical (a.k.a. subdural, epipial) surface electrodes, these recordings have also been used to investigate the neural correlates of a variety of human brain functions, including movement and speech. In recent years, the long-term stability of these recordings and the widespread availability of clinical subjects has also led investigators to explore iEEG as signal source for brain-computer interfaces (BCI's) However, the success of this approach requires the solution of a perennial problem in EEG signal analysis: what components of these complex signals are meaningful and what do they mean? One way to try to answer this question has been to study event-related changes in the EEG power spectrum. Using this approach iEEG studies have contributed important insights into the spatial-temporal response characteristics of different EEG spectral components. For example, these studies have shown functional brain activation is consistently associated with broadband iEEG power increases at high gamma frequencies (~60-200 Hz). The spatial and temporal specificity of this particular signal change, and its observation in every functional-anatomic domain of human cortex, has motivated recent studies of its neurophysiological mechanisms in animals. These studies have shown that broadband high gamma responses are highly correlated with increases in population firing rates and may even contain energy from action potential currents. These responses could also be sensitive, particularly at the level of ECoG, to the degree of synchronization in population firing. Recent iEEG studies have suggested that high gamma responses are not uniformly broadband and could contain band-limited oscillations in sub-populations of neurons. This would be of potential relevance to decoding strategies in brain-computer interfaces. On the other hand, other investigators have argued that high gamma responses are part of an increase in signal energy across all frequencies, but that most energy increases in lower frequencies are obscured by power decreases that reflect slower, more widespread control mechanisms. Interestingly, some of these low frequency components have also been used as effective features in BCI's.

Future studies of iEEG spectral features could be relevant to both BCI applications and to ongoing debates about neural coding and the interpretation of oscillatory activity at both low and high frequencies.

Nathan Crone is Associate Professor of Neurology at Johns Hopkins University School of Medicine. His clinical expertise is in epilepsy and clinical neurophysiology and he has an ongoing research program using intracranial EEG in clinical subjects to conduct cognitive neuroscience investigations, including studies of the human cortical correlates of motor and language function. Dr. Crone has been particularly interested in the characterization and application of physiological gamma responses.

What are the 'units' for noninvasive decoding of fine dexterous movements? Jose 'Pepe' L. CONTRERAS-VIDAL, Departments of Kinesiology & Bioengineering, and the Neuroscience and Cognitive Science Program, University of Maryland School of Public Health**,** 20742 College Park, USA {pepeum@umd.edu}

We have recently shown the feasibility of inferring natural movements from the amplitude modulations (AM) of a plurality of scalp EEG signals in the delta (< 5 Hz) frequency band using linear decoders. Our noninvasive EEG-based interfaces and algorithms allow us to selectively read out brain activity patterns naturally correlated with movement intentions, which in turn allows users to achieve brain-computer interface (BCI) control of 'neural' cursors within a single session of training. These demonstrations challenge the perceived limitations of scalp EEG as a source signal for 'reading' the brain, while providing an opportunity for the application of noninvasive brain-machine interface (BMI) in neural, cognitive, and rehabilitation engineering. In this presentation, I will also review our recent efforts on developing noninvasive BMIs for the control of the DARPA multifunctional modular prosthetic limb (MPL).

Dr. Contreras-Vidal's research program integrates behavioral, neuroimaging, and computational neuroscience methods to study the neural mechanisms and computational principles underlying human adaptive sensory-motor control and learning across the lifespan under normal and neurological conditions. To accomplish the above goal we employ motion recording, high-density scalp electroencephalography (EEG), magnetoencephalography (MEG), functional near infrared spectroscopy (fNIR), and computer simulations of large-scale, biologically-plausible, neural networks of motor systems including the spinal cord, fronto-parietal networks, the basal ganglia and the cerebellum. His translational research involves the development of smart neuroprosthetics, and the transfer of relevant biological principles (hardware and algorithms) to the design and development of a new generation of artificial hands and arms (bio-robotics). For more information visit: http://www.sph.umd.edu/KNES/faculty/jcontrerasvidal/index.html

Is it possible to facilitate BMI learning by non-invasive brain stimulation? Surjo SOEKADAR, University of Tübingen, Germany and Human Cortical Physiology and Stroke Neurorehabilitation Section of the National Institutes of Neurologic Disorders and Stroke, USA.

Abstract: The development of non-invasive and invasive BMI systems that translate electric or metabolic brain signals into control commands of external devices has experienced an impressive growth over the last years. They usually rely on the subjects' need to control neural activity. The more rapid and accurate the control of such activity, the more effective BMI systems are. Thus, optimizing learning is likely to result in more effective BMIs. In the motor domain, learning can be improved through designing practice protocols (as in the contextual interference effect) and/or by combining practice with stimulation of the central nervous system in the form of transcranial magnetic (TMS) or direct current (TDCS) stimulation that can facilitate learning effects. Thus, noninvasive brain stimulation techniques can facilitate different stages of motor skill learning. Subsequent experiments demonstrated that these stimulation techniques can modulate brain rhythms. Some of these rhythms are often utilized to control BMI systems, as for example m-rhythms. Here, we pose the hypothesis that practice to control a BMI system based

on voluntary modulation of m-rhythms could be facilitated by concurrent application of non-invasive cortical stimulation over the brain regions engaged in the generation of those rhythms. If so, this could evolve into a useful tool to improve the ability of patients with different impairments, to control more rapidly and accurately BMI systems. Preliminary data support this hypothesis. We found that 20 minutes of anodal TDCS delivered immediately before BMI training improved reliable production of event-related desychronization (ERD) of SMR. Analysis of neurophysiologic correlates of this improvement indicated that tDCS improves consistency of ERD production and optimal timing of desynchronization. We propose that the combination of brain stimulation and BMI practice promises optimization of training-protocols for both, assistive and restorative BMI applications and might help to further elucidate mechanisms underlying optimized control of BMIs.

Surjo R. Soekadar is currently Fellow at the Human Cortical Physiology and Stroke Neurorehabilitation Section of the National Institutes of Neurologic Disorders and Stroke (NINDS). He studied medicine in Mainz, Heidelberg and Baltimore and received his doctorate in 2005 on "neuroplasticity and phantom limb pain" (advisor: Herta Flor). His current work focuses on the combination of brain stimulation and BMI technology, work conducted in tight collaboration between the University of Tübingen (Niels Birbaumer) and the NINDS (Leonardo G. Cohen) supported by the German Ministry of Education and Research (BMBF) and German Research Foundation (DFG). He received various prizes, e.g. the NIH-DFG Research Career Transition Award and NIH Fellows Award for Research Excellence.

What information is contained in the brain's 'noise' that could be harnessed by BMI?

Christopher GUGER, g.tec medical engineering GmbH/Guger Technologies OG, Herbersteinstrasse 60, 8020 Graz, Austria {guger@gtec.at}

The possibility of brain-computer communication based on the electroencephalogram (EEG) has been discussed almost four decades ago. In another pioneering work, Farwell and Donchin described the use of evoked potentials for communication. Up to the early 2000s, no more than 5 groups were active in brain-computer interface (BCI) research. Now, about 200-300 laboratories are focused on this work. This dramatic growth has been driven by high performance and low cost of computing power and related instrumentation, increased understanding on normal and abnormal brain function, and improved methods for decoding brain signals in real time. As a result, the performance and usability of BCI systems have advanced dramatically over the past several years. BCI systems can be described by the following characteristics: (i) invasive (electrocorticogram (ECoG), spikes) or non-invasive (EEG, NIRS (near infrared-spectroscopy), fMRI (functional magnetic resonance imaging), MEG (magnetoencephalogram)) systems, (ii) portable (EEG) or stationary (fMRI, ECoG, spikes), (iii) according to application area (spelling, wheelchair control, brain painting, research,...), (iv) type of BCI principle used (P300, SSVEP (steady-state visual evoked potential)), SSEP (steady-state evoked potential)), motor imagery, slow cortical potentials (v) speed and accuracy, (vi) training time and reliability, (vii) synchronous and asynchronous, (viii) low cost (EEG, NIRS) and high costs (MEG, fMRI, spikes), (ix) degrees of freedom. The advantages and disadvantages of the different BCI systems will be discussed based on the BCI Award 2010 with 57 BCI project submissions. Of particular interest is the high percentage of real-time BCI implementations that exist nowadays. Motor imagery is still the mostly used strategy to control a BCI, followed by P300 and SSVEP. It is also not surprising that mostly EEG-based BCI systems are used because they are easier to handle and are cheaper. Thus far it is not known whether a BCI system can be developed that utilizes activity from more central structures of the brain. The mostly implemented application is spelling, ahead of general control and stroke rehabilitation, wheelchair/robot or Internet control.

Christoph Guger studied biomedical engineering at the University of Technology Graz and Johns Hopkins University in Baltimore, USA. Then he carried out research work at the Department of Medical Informatics

(Prof. Pfurtscheller) at the University of Technology Graz and received his PhD degree in 1999. The topic of his PhD work was the design of an EEG-based brain-computer interface. This was the first real-time BCI system with continuous feedback. He also developed the real-time analysis with common spatial patterns which is still the fastest and most accurate approach for oscillatory BCIs and developed also a P300 BCI with very high accuracy and speed. In the last years he worked also with ALS and tetraplegic patients in different countries. He is co-founder of g.tec where he works since 1999. Currently he is principal investigator of several European Union research projects.

CONTRIBUTED SESSION (Chair: Arend Van Gemmert): FORENSIC SCIENCE, HANDWRITING AND DRAWING

Dynamic Signature Features from Static Greyscale Information. Martino BACILE DI CASTIGLIONE and Richard GUEST**,** *School of Engineering and Digital Arts, University of Kent, Canterbury, CT2 7NT, UK* **{**mabadica@gmail.com, r.m.guest@kent.ac.uk**}**

Abstract. Inference of dynamic constructional information from handwriting is commonly employed by Forensic Document Examiners for assessment of writing samples. In this paper we assess a number of standard image processing techniques for texture analysis in an attempt to automatically infer pen pressure, tilt and velocity from signature images. Furthermore, we use a series of machine-learning classifiers to predict category ranges referenced against ground-truth data. Our study shows that particular classifiers are able identify the inferred dynamic bin with around 70% accuracy. This figure is significantly enhanced by combining the decisions of several classifiers, with high accuracy (87%) inferred for pen pressure data. These results indicate the practical application of employing texture analysis within forensic signature analysis systems.

Forensic Requirements for Automated Handwriting Analysis Systems. Reinier J. VERDUIJNa, C. Elisa VAN DEN HEUVELa, Reinoud D. STOEL, Netherlands Forensic Institute (Department of Digital Technology and Biometrics), Laan van Ypenburg 6, 2497 GB, The Hague, THE NETHERLANDS {r.verduijn, e.van.den.heuvel}@nfi.minjus.nl, {reinoud@holmes.nl}

Abstract. This paper provides a discussion of the utilization of automated handwriting recognition software in forensics, with reference to theoretical issues associated with the handwriting examination paradigm. Topics that are discussed consider: the relevancy of the output; the need for adjustable hypotheses; the order of document examination; and problems of the current pattern recognition approaches regarding handwriting characteristics. Here the CEDAR-FOX system is used to explain these issues, nevertheless notice that some issues also apply to most other automated forensic handwriting analysis systems. In order to perform forensic handwriting analysis expertise automatically in the future, we need to bridge the gap and start the discussion between forensic handwriting experts and handwriting recognition researchers.

A Cognitive Look into Simulations of High and Low Complexity Signatures. Avni PEPE, Douglas K. ROGERS and Jodi C. SITA, *Handwriting Analysis and Research Laboratory, School of Human Biosciences, La Trobe University, 3086, Victoria, AUSTRALIA* {a.pepe, d.rogers, j.sita}@latrobe.edu.au

Abstract. The difficulty with which a signature can be simulated has been considered to be related to elements associated with its complexity, with more complex signatures assumed to be harder to simulate as compared to less complex ones. In this study, eye movements and handwriting dynamics were examined during subjects' attempts at simulating two model signatures of different complexities. It was found that significantly more fixations were made on the model signatures than the simulated signatures for both the low and high complexity

simulations. Subjects made significantly more fixations on the high complexity model signature, compared to the low complexity model signature and these fixations had longer durations. The duration of fixations on the simulated signatures did not differ between the complexity conditions. When asked to nominate which model signature would be harder to simulate, during pre-simulation, the majority of subjects nominated the high complexity signature, however, only a few retained this view post-simulation. Although gaze data did lend support to contemporary views as to how signature complexity may be modeled, it appears that there are other factors contributing to complexity that have yet to be incorporated into the model tested.

Dominant points for Spatio-graphic and Procedural analysis of online drawings. Ney RENAU-FERRER, Céline REMI, *LAMIA Laboratory, University Antilles Guyane 97110, Point à Pitre, GUADELOUPE* {nrenaufe, cremi}@univ-ag.fr

Abstract. Many possibilities are offered by online acquisition devices: shape recognition, beautification, signature verification, procedural analysis etc. Most of the time, before performing any upper level analysis, one has to perform a segmentation step, eventually providing a set of feature points. In this paper we address the question of selection, specification, specialization and labelling of those points that we consider to be an important step to allow multi-level analysis of sketches.

Validating Features for Inferring Handwriting Speed from Static Trace. Emily J. WILL *Q.D.E.Will, Raleigh, North Carolina, USA* {ewill@Qdewill.com}

Abstract. The goals of this study were to determine whether FDEs can correctly infer speed from the static trace, and whether traditional factors used by FDEs to do this can be validated. One writer wrote the word “thinking” on a graphics tablet twenty times at varying speeds. The writing was recorded by an inking pen at a sampling rate of 100 Hz. Duration was measured using MovAlyzeR™ software. Words were paired and high resolution scans of these pairs were presented to participants who were asked to select the faster writing of each pair and to list the factors used to make decisions. Guessing was discouraged. Results showed that FDEs can make correct inferences of handwriting speed from the static trace. Factors most often relied upon to indicate speed were good line quality, rounded (not angular) shapes, simplification, illegibility, right trend and tapered beginning and ending strokes.

THE INFLUENCE OF THE USE OF A QUILL PEN ON A SCRIBE’S ABILITY TO ACCURATELY COPY A MUSIC MANUSCRIPT. Bryan FOUND and Martin JARVIS, *Handwriting Analysis and Research Laboratory, School of Human Biosciences, La Trobe University, Bundoora VIC 3086, AUSTRALIA and Document Examination Unit, Victoria Police Forensic Services Department, Macleod VIC 3085, Victoria, AUSTRALIA* and the *Charles Darwin University School of Creative Arts & Humanities, Darwin AUSTRALIA*

Abstract: In the 18th century the standard writing implement was the quill pen. It has been argued that the use of the quill could have influenced the music-copyists, making it more likely that they would imitate or emulate the music-calligraphy of the original work of the composer, especially if the copyist used a quill cut by the composer.1 This small pilot study investigates what influence, if any, the quill pen has on the scribe’s ability to accurately reproduce music and whether cutting their own quill produces any perceivable impact.

CONTRIBUTED SESSION (Chair: Annie Vinter): HANDWRITING ANALYSIS AND TECHNOLOGY

MokkAnnotator - An Annotation Tool to Accumulate and Organize Mokkans. Truyen Van PHAN[a], Hajime BABA [b], Akihiro WATANABE [b], and Masaki NAKAGAWA [a], [a] *Graduate School of Technology, Tokyo University of Agriculture & Technology*, *2-24-16, Naka-cho, Koganei, 184-8588, Tokyo, JAPAN* and [a]*bNara National Research Institute for Cultural Properties*, *2-9-1 Nijyo-cho, Nara, 630-8577, Nara, JAPAN* {truyenvanphan@gmail.com, hajime@nabunken.go.jp}

Abstract. This paper describes an annotation tool to accumulate and organize mokkans. A mokkan is a generic name given to Japanese historical wooden tablets that have handwritten characters. More than 180,000 of the 320,000 mokkans unearthed in Japan come from excavations from Heijyo-Palace (the ancient palace in the Nara period). The number is increasing as the excavations in the larger remaining part in Heijyo-Palace and other areas continue. Since then, it is necessary to build an effective tool for registration and management of mokkans. MokkAnnotator has been developed and released as a comprehensive tool that we hope will ease the burden of mokkans accumulation and organization, also encourage additional sharing of data. On annotation, an image of about 10 mokkans on a glass plate is interpreted as a set of zones; each zone represents a singular mokkan. Users can draw and edit zones easily, also annotate archaeological information of mokkan rapidly.

Segmenting Isolated Characters within Cursive Words. Antonio PARZIALE[a], Claudio DE STEFANO[b] and Angelo MARCELLI[a], [a] Natural Computation Lab, DIEII, University of Salerno Via Ponte Don Melillo, 1, 84084, Fisciano(SA), ITALY and [b] DAEIMI, University of Cassino, Via Di Biasio, 43 , 03043 Cassino (FR), ITALY {antonio.parziale@gmail.com, destefano@unicas.it, amarcelli@unisa.it}

Abstract. The large majority of the methods proposed in literature for handwriting recognition assume that any word is produced without lifting the pen, other than horizontal bars and dots. This fundamental assumption, however, does not always hold: while some educational systems provide explicit training for producing continuous handwriting, minimizing the number of pen-up during the production of a word, others do not. As a consequence, whenever the handwriting presents penup within a word, the performance can drop significantly. We present an algorithm for discriminating among different types of ink appearing in handwriting, namely isolated characters, cursive, dots, horizontal and vertical bars. The algorithm assumes as input the bit map of the entire word, subdivides it into sub-images, each containing a connected component of the ink, and classifies each sub-image depending on the aspect ratio of the bounding box surrounding the connected components, as well as on statistics on the pixel of the sub-image. The experimental results, obtained on a large data set of actual mail show that the proposed method successfully achieves its aim and may contribute to improve the overall performance of a cursive handwriting recognition system.

Age-Related Changes In Executive Control And Their Relationships With Handwriting Performance. Sara ROSENBLUM[a], Yael FOGEL[b] and Batya ENGEL-YEGER[a], [a]*University of Haifa, Department of Occupational Therapy, Faculty of Social Welfare and Health Sciences, 31905, Mount Carmel, Haifa, Israel* and [b]*"MFTECH" Therapy Center*, *44855, Karnei Shomron, Israel*, {rosens@research.haifa.ac.il, yfogel@gmail.com, bengel@univ.haifa.ac.il}

Abstract: Objectives: Deterioration in the frontal and prefrontal cortex associated with Executive Functions (EF) that occur with age may influence activity performance, such as handwriting. The study's aim was to describe changes occurring with age in EF and handwriting activity, through performance-based evaluations. Furthermore, to analyze whether executive control is a mediator in prediction of age related changes in handwriting performance. **Participants**: 80 healthy participants (aged 31 - 76+) living in the community. **Design**: All participants performed the

Behavioral Assessment of the Dysexecutive Syndrome (BADS) and handwriting tasks on a digitizer included in the Computerized Penmanship Evaluation Tool (ComPET). **Results**: Significant differences were found between age groups for both EF and handwriting measures. Linear regression indicated that the EF control explained 31% and the age explained 42% of variance of handwriting time per stroke in air while writing. **Conclusions**: The result of this study indicates that handwriting process measures may be an effective way of evaluating the decrease in EF in the elderly, by means of a functional activity.

Wednesday June 15th

PLENARY SESSION (Sponsored by IGS):
Ranulfo Romo, Institute of Cellular Physiology, National Autonomous University of Mexico,
"Conversion of sensory signals into decision making"

A fundamental goal of neuroscience is to understand how subjective sensory experiences arise from the activity in the brain. A major component of this problem involves understanding how the brain represents sensory features. Pioneering investigations in several sensory systems have shown how neural activity represents the physical parameters of the sensory stimuli both in the periphery and in the central areas of the brain. These investigations have paved the way for new questions that are more closely related to cognitive processing. For example, where and how in the brain do the neuronal responses that encode the sensory stimuli translate into responses that encode a perceptual decision? What components of the neuronal activity evoked by a sensory stimulus are directly related to perception? Where and how in the brain sensory information is stored in memory? These questions have been investigated in behavioral tasks where the sensory stimuli are under precise quantitative control and the subject's psychophysical performances are quantitatively measured. One of the main challenges of this approach is that even the simpler cognitive tasks engage large number of cortical areas, and each one might render the sensory information in a different way. Also, the sensory information might be combined in these cortical areas with other types of stored signals representing, for example, past experience and actions. Here I discuss several such pieces, although, in the log run, I aim for an integrated understanding of how subjective sensory experience arises in the activity of the brain, at least to the extent possible within the minimalist environment of laboratory tasks.

Ranulfo Romo is Professor of Neuroscience at the Institute of Cellular Physiology, National Autonomous University of Mexico (UNAM). He received his M.D. degree from UNAM and a D.Sc. in the field of neuroscience from the University of Paris in France. His postdoctoral work was done with Wolfram Schultz at the University of Fribourg in Switzerland and Vernon Mountcastle at The Johns Hopkins University. Romo has received the Demuth Prize in Neuroscience from the Demuth Foundation, the National Prize on Sciences and Arts from the Mexican government and the Prize in Basic Medical Sciences from the Academy of Sciences for the Developing World (TWAS). He is a member of the Mexican Academy of Sciences, the Neurosciences Research Program headed by Nobel Prize Gerald Edelman and a Foreign Associate of the National Academy of Sciences. Since 1991 Romo is a Howard Hughes International Research Scholar and recently was elected member of El Colegio Nacional.

CONTRIBUTED SESSION (Chair: Elisa Van den HEUVEL): MOVEMENT NEUROSCIENCE II

Function of the basal ganglia system for cognitive and motor tasks. Raymond CHONG
Department of Physical Therapy, Georgia Health Sciences University, Augusta, Georgia 30912, USA
{rchong8@hotmail.com}

Abstract. What is the function of the basal ganglia system in cognition and motor control/learning? Researchers have tried to operationalize it using descriptors which suggest its

involvement in the internal guidance of movement, reliance on external cues, activation/suppression of neural pathways, procedural learning, etc. In the presentation, we focus on another function ascribed to the basal ganglia system: set-shifting (or changing set). Set-shifting deficits will be illustrated in three tasks: a cognitive task (voluntary key-press activity), a learning task (optical prism adaptation) and an involuntary task (stance balance control). The illustrations are all based on the human Parkinson's disease (PD) model but evidence from other imaging, animal, children and other adult human studies are also consistent with the general concept of set-shifting function of the basal ganglia function. The illustrations will be followed by a consideration of selected publications on handwriting in PD. The overall goal of the presentation is not to review the basal ganglia system but to stimulate scientific discussions on whether some of the handwriting/fine motor control deficits seen in people with PD might be related to their set-changing insufficiency.

The Macrostructure of Rest Tremor in Parkinson's Disease. Shikha PRASHAD[ab], Anusha VENKATAKRISHNAN[abd], José L. CONTRERAS-VIDAL[abc], [a]*Graduate Program in Neuroscience and Cognitive Science*, [b]*Department of Kinesiology,* [c]*Fischell Department of Bioengineering , University of Maryland, College Park, MD, 20742, USA*, [d] *Human Cortical Physiology and Stroke Neurorehabilitation Section, National Institutes of Health, Bethesda, MD, USA* {sprashad, anushav, pepeum}@umd.edu

Abstract. Movement abnormalities in Parkinson's disease (PD) have been traditionally analyzed locally (e.g., head, hand, arms or lower limbs) and thus, it is unknown if and how these abnormalities are interrelated and expressed in the whole body. Here, 3D motion capture systems were used to record whole body movements from PD patients (n = 8) and controls (n = 8) as they performed functional movements including those from the Unified Parkinson's Disease Rating Scale (UPDRS) as well as activities of daily living such as bouncing a ball, combing hair, cutting a slice of bread, walking, and rising from a chair. We present initial findings from Principal Component (PCA) and spectral analyses that can distinguish the patient group from the control group based on the analysis of motion data from five endpoints (left and right hands and ankles, and head) during postural tremor assessment in static seated conditions. Our results suggest that it is possible to extract meaningful information from whole body 3D data to discriminate between PD patients and healthy adults. These findings appear to be a promising advance toward the eventual goal of identifying noninvasive bio-markers for diagnosis, evaluation and tracking of the progression of PD.

Development of Cross-modal Interactions in School-Aged Children. Florian A. KAGERER[a] and Jane E. CLARK[b], [a]Dept. of Kinesiology, Michigan State University, 27 IM Sports Circle, East Lansing, MI 49924, USA, [b]Dept. of Kinesiology, University of Maryland, College Park, MD 20742, USA {fkagerer@msu.edu, jeclark@umd.edu}

Abstract: Reliable sensory-motor integration is a pre-requisite for optimal movement control; this integration seems to change during development. Previous research has shown that motor performance of school-aged children is characterized by higher variability, particularly under conditions where vision is not available, and feedforward and feedback control is largely based on kinesthetic input. The purpose of the current study was to determine how different sensorimotor internal models interact with each other. To this end, we induced a visuo-motor adaptation in 61 children, ranging from 5 to 12 years of age, and measured the initial directional error (IDE) during a subsequent condition where visual feedback was not available, and participants had to rely on kinesthetic input. Preliminary results showed that older children (9-12 years old) de-adapted significantly more than younger children (5-8 years old) over the course of 36 trials, suggesting that the kinesthetic-motor internal representation in the older children was utilized more efficiently in the absence of vision.

CONTRIBUTED SESSION (Chair: Rejean Plamondon): FORENSIC SCIENCES II

Exploratory Investigation on the Performance of the CEDAR-FOX System for Forensic Handwriting Verification and Identification. Reinier J. VERDUIJN, C. Elisa VAN DEN HEUVEL, Reinoud D. STOEL, Netherlands Forensic Institute (Department of Digital Technology and Biometrics), Laan van Ypenburg 6, 2497 GB, The Hague, THE NETHERLANDS {r.verduijn, e.van.den.heuvel, reinoud@holmes.nl}

Abstract. Forensic handwriting analysis relies on human judgment, and is often criticized for its lack of objectivity. In order to reduce the inherent subjectivity of handwriting analysis, automated analysis systems have been proposed. Automated analysis systems measure handwriting features objectively and in a constant manner. To investigate whether automated forensic handwriting analysis could be viable in practice, a case study was performed using the automated handwriting analysis system CEDAR-FOX. First, it is examined how CEDAR-FOX works with several simple tests. Next, the performance of CEDAR-FOX is compared to that of forensic handwriting experts (FHEs). The results show that difficult to use CEDAR-FOX in forensic casework due to the difficult interpretation of the output. Nevertheless CEDAR-FOX proved to be useful when searching for documents with a similar appearance, although it seems not fit for determining the strength of the evidence.

Dynamic Features of Naturally Written, Disguised and Forged Handwritten Text. Carolyne L BIRD [a, b], Bryan FOUND [a, c], Kaye N BALLANTYNE[d] and Douglas ROGERS [a]
[a]Handwriting Analysis and Research Laboratory, School of Human Biosciences, La Trobe University Bundoora, Victoria 3086, AUSTRALIA; [b]Document Examination Section, Forensic Science SA, 21 Divett Place, Adelaide, South Australia 5000, AUSTRALIA; [c]Document Examination Unit, Victoria Police Forensic Services Department, Macleod Victoria 3085, AUSTRALIA,; [d]Biology Division, Victoria Police Forensic Services Department, Macleod Victoria 3085, AUSTRALIA {carolyne.bird@sa.gov.au, b.found@latrobe.edu.au, kaye.ballantyne@police.vic.gov.au, d.rogers@latrobe.edu.au}

Abstract. Assessing the process of production of handwriting (naturally written, disguised or forged) is an important step in forensic examination methodology. Although forensic examinations are made on static images, dynamic information, such as pen pressure, fluency, and velocity, is inferred and can impact on opinions regarding handwriting processes. This study investigates dynamic differences between naturally written, disguised and forged handwritten text made by eleven sets of writers. Each target writer wrote a specific paragraph in both their natural lowercase handwriting style and using a disguise. Another writer then wrote the same paragraph attempting to forge the target writer's natural handwriting features. Significant differences were found between all handwriting types for three of the four dynamic features measured (duration, relative pen down duration and average absolute velocity). The strongest effect, when interindividual variation was discounted, was associated with the velocity measure. These results support anecdotal and limited empirical evidence that, with reliable static estimations, velocity may be used to discriminate between disguised and forged handwriting behaviour.

The Relation Between Signature Complexity and the Perceived Quality of Signature Simulations. Erwin J.A.T. MATTIJSSENa, C. Elisa VAN DEN HEUVELa and Reinoud D. STOEL; *Netherlands Forensic Institute (Department of Digital Technology and Biometrics), Laan van Ypenburg 6, 2479 GB, The Hague, THE NETHERLANDS {e.mattijssen, e.van.den.heuvel, r.stoel}@nfi.minjus.nl*

Abstract. Found et al. (1998) theorized that the complexity of a signature relates to the actual quality or success of a simulation. The legibility of a signature is also expected to have an effect

on the quality of a simulation (Alewijnse et al. 2009, in press; Alonso-Fernandez et al., 2007). This paper focuses on the effect of signature complexity and legibility on the quality of simulations produced by expert penmen and judged for authenticity by forensic handwriting experts. Signature complexity and legibility was determined of 63 authentic signatures. Expert penmen simulated several of the authentic signatures. Five forensic handwriting experts (FHEs) were asked to give an opinion on the underlying source of 200 questioned signatures of which 54 were authentic signatures and 146 were simulated signatures. Misleading scores occurred on signatures that were relatively low in complexity and less legible compared to the signatures for which correct scores were given. Viewing FHEs' scores as a predictor of simulation quality, the results confirm the theorized relationship between signature complexity, signature legibility and the quality of simulations, supporting the claims made by Found et al. (1998) and Alonso-Fernandez et al. (2007).

CONTRIBUTED SESSION (Chair: Arend Van Gemmert): HANDWRITING ANALYSIS

Determining Cursive or Printed Nature of Handwritten Samples. Gregory BALL, Danjun PU, and Sargur SRIHARI, *Center of Excellence for Document Analysis and Recognition, State University of New York at Buffalo*, *UB Commons, 520 Lee Entrance, Suite 202*, *Amherst, NY 14228, UNITED STATES* {grball, srihari}@cedar.buffalo.edu

Abstract. Forensic document examiners tend to compare documents to one another only when they are both cursive or both hand printed documents. Thus, for an automated system to process writer identification or verification, it is desirable to determine whether a sample of handwritten text is of a hand printed or cursive nature. We identify a feature based upon the number of segmented words and number of connected components which are identified as single characters. We evaluate the performance of this feature by using all 4,701 documents present CEDAR letter dataset and find that using this feature identifies documents as hand printed correctly 95% of the time and identifies them as cursive 91% of the time.

Kinematic Analysis of Handwriting in Pupils of Primary and Secondary School. Mariangela GENNA[a], Agostino P. ACCARDO[a] and Michela BOREAN[b], [a]*Department of Industrial Engineering & Information Technology, University of Trieste*, *Via Valerio, 10 I34100, Trieste, ITALY;* [b]*Child Neurology and Psychiatry Unit, Dept. of Pediatrics, IRCCS Burlo Garofolo,Via dell'Istria, 65/1 I34100, Trieste, ITALY* {mariangela.genna@phd.units.it, accardo@units.it, michela.borean@libero.it}

Abstract. Handwriting represents a complex motor behaviour in which linguistic, psychomotor and biomechanical processes closely interact with maturation, development and learning. In recent years, the analysis of handwriting movements has been directly performed through digitizing tablets. This technology allows objective quantitative kinematic analyses of writing quality and has been used to characterize the handwriting process (Rosenblum & al., 2006) by measuring parameters extracted from the basic elements of writing, such as components and strokes. In this paper we investigated a series of kinematic parameters such as length, duration, mean and peak velocity of components and strokes of handwriting movements accomplished by 105 mainstream school-aged children, examining how these parameters change as schooling proceeds. Writing was acquired by a digital tablet and its dynamic aspects were studied in two different experimental conditions: repeating a cursive sequence of *le* and of numbers, in ascending order. Main results show an increase, as schooling advances, in mean and peak horizontal and curvilinear velocities of components and strokes and a decrease of number of strokes to realize each letter. We conclude that some of these kinematic parameters are useful for handwriting development studies.

Handwriting in children with autism and Asperger's disorder. Beth P JOHNSON, Nicole PAPADOPOULOS, Joanne FIELDING, James G PHILLIPS and Nicole J RINEHART, Centre for Developmental Psychiatry & Psychology, School of Psychology and Psychiatry, Monash University, Building 1, 270 Ferntree Gully Road, Notting Hill, Victoria, 3168 AUSTRALIA and School of Psychology and Psychiatry, Monash University, Building 17, Clayton Campus, Wellington Road, Monash University, Victoria, 3800 AUSTRALIA {beth.johnson, nicole.papadopoulos, joanne.fielding, nicole.rinehart, jim.phillips}@monash.edu.au

Abstract. Handwriting difficulties in children with autism spectrum disorders account for a large proportion of occupational therapists" caseloads, yet the nature of handwriting deficits in this group remains unknown. In this study, kinematic measurements of handwriting movements were assessed in children with high functioning autism (HFA) and Asperger's disorder (AD). Participants performed four cursive letter "l"s on a graphics tablet, with 10mm and 40mm lined cues, and at their preferred size. Children also wrote the phrase "cat and dog" as many times as possible on lined paper within a two minute period. Average letter height and size consistency was comparable between clinical groups and typically developing children during the 10mm and 40mm cued tasks. However, in the absence of visual cues, the preferred size of cursive letter "l"s across increased dramatically in children with autism and AD, suggesting that handwriting size is driven by contextual and visual guides. Furthermore, there was reduced space, and more variable space between words on the "cat and dog" task in the clinical groups, which may contribute to their poor handwriting legibility. Strategies for improving performance in handwriting in autism and AD will need to consider the importance of visuo-spatial and contextual cues in these populations.

Handwriting in children with attention deficit hyperactivity disorder. Rebecca A LANGMAID, Beth P JOHNSON, Nicole PAPADOPOULOS, Nicole J RINEHART and James G PHILLIPS, Centre for Developmental Psychiatry & Psychology, School of Psychology and Psychiatry, Monash University, Building 1, 270 Ferntree Gully Road, Notting Hill, Victoria, 3168 AUSTRALIA, and School of Psychology and Psychiatry, Monash University, Building 17, Clayton Campus, Wellington Road, Monash University, Victoria, 3800 AUSTRALIA {rebecca.langmaid, beth.johnson, Nicole.Papadopoulos, nicole.rinehart, jim.phillips} @monash.edu.au

Abstract. Handwriting difficulties commonly observed in children with ADHD combined type (ADHD-CT) may serve as a potential endophenotype of the disorder. This study aimed to characterize motor impairment in a handwriting task using a digitising tablet. 14 boys with ADHD-CT and 14 age, sex and IQ matched typically developing (TD) children, aged 7-15, drew a series of four _l's on a digitising tablet at their preferred size, 10mm and 40mm sizes. Children also had two minutes to write the phrase _cat and dog' as many times as possible on lined paper. Analyses revealed that children with ADHD-CT had more variable writing size than TD children in the preferred size and cat and dog task. This was not present in the visually cued (10mm and 40mm) conditions. The ADHD-CT group also performed more efficient movement in the visually cued conditions although exhibited smaller vertical size increases in the 40mm loops condition compared to TD controls. It was concluded that motor impairment in children with ADHD is characterized by a pattern of inconsistent movement extent, which may be modulated with the provision of visual guidelines. Additionally, these findings provide further support of subtle handwriting anomalies that may be associated with deficits in fronto-striatal- cerebellar brain circuitry in ADHD. This has important clinical implications for educational and occupational therapy settings where handwriting impairments may be improved by the use of visual cues.

Developmental study of graphic coordination dynamics: Preference for a circular over an elliptic trace. Jérémy DANNA[a], Sylvie ATHENES[b], Fabienne ENDERLI[a] and Pier-Giorgio ZANONE[a],

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Abstract. Using concepts and tools of a dynamical system approach in order to understand motor coordination underlying graphic skills, our aim is to establish whether the basic coordination dynamics found in adults is already established in children at elementary school, when handwriting is trained and eventually acquired. Forty-five children volunteered to copy two series of 13 ellipsoid shapes. These shapes were generated by manipulating the relative phase of two orthogonal oscillators in two orientations. Findings showed that children reproduced lines and circle precisely from an early age on. Comparing results with previous studies on adults, the graphic coordination dynamics in children seems to be different from that found in adults and not to be affected by the intensive training of handwriting undergone during this period. The tendency to write in a rounder fashion persists until the age of 11, implying that the basic adult coordinated activity appears later, possibly due to increasing writing speed.

Does Motor Compatibility influence the grouping of upper-case Handwritten Letters?
Aurélie LAGARRIGUE [a,b], Marieke LONGCAMP [b,c], Jean-Luc NESPOULOUS [a] and Jean-Luc VELAY [b],
[a]*Laboratoire Jacques Lordat (Unité de Recherche Interdisciplinaire OCTOGONE, EA 4156)*, *Toulouse, France;* [b]*Institut de Neurosciences Cognitives de la Méditerranée (UMR CNRS 6193), Marseille, France;* [c]*Laboratoire Adaptation Perceptivo Motrice et Apprentissage (Université Paul Sabatier, UFR STAPS)*, *Toulouse, France* {lagarrigue@incm.cnrs-mrs.fr, longcamp@cict.fr, nespoulous@univ-tlse2.fr, velay@incm.cnrs-mrs.fr}

Abstract. The rules governing letters associations when words are written have not been extensively studied. Several factors may intervene for grouping together letters and creating chunks which would be written faster. Linguistic constraints may induce such chunks. For instance, it has been shown that the time separating two letters is shorter when they belong to the same syllable than when they belong to two adjacent syllables. Motor associations might also play a role in the way letters are chunked. Motor compatibility between letters might favor some associations and the creation of motor chunks which could modify or even reverse the linguistic effects. We propose a set of principles defining the motor compatibility between two upper-case letters. We investigated motor chunks by measuring the duration, length and smoothness of the displacement between two letters. The results showed that when one of the two letters begins or ends with a right-to-left stroke, they are more difficult to link together.

CONTRIBUTED SESSION (Chair: Masaki Nakagawa): BRAIN-MIND-MACHINES II

Towards an Ink-Enabled Handwriting Editor.
Hala BEZINE, Sourour NJAH and Adel M. ALIMI,
Research Group on Intelligent Machines, National School of Engineers of Sfax, BP. W, 3038, Sfax, Tunisia {hala.bezine, sourour.njah, adel.alimi} @ieee.org

Abstract. The human being wants to communicate with the computer in the simplest, fastest way to facilitate and accelerate the interaction and the exchange of information. He seeks to make these machines, able to read, see, move, treat and quickly analyze the information received. Because pen-based computing becomes more prevalent, it is increasingly important to share the ink across applications and platforms. Indeed, handwriting can be a powerful entry for computing and communication, and InkML provides cross-platform environment to support it. In this paper, we have developed an Ink-enabled handwriting editor; we describe our tool, which enclose the presentation of handwriting scripts acquired by the user via a digitizing tablet using a special stylus and stored in an XML file. Also, It deals with the transformation of the XML file to another

editable format (Word, latex, html...etc). This last provides a greater ease of editing documents including an experimental environment for studying the effects of varying the parameters that influence the access facility of ink-files and evaluating the performance of our system. As future works we have to enhance the recognition performance of on-line Arabic scripts.

Evaluation of Continuous Marking Menus for Learning Cursive Pen-based Commands. PeiYu LI, Adrien DELAYE and Eric ANQUETIL, *INSA de Rennes, Avenue des Buttes de Coësmes, F-35043 Rennes*, *UMR IRISA, Campus de Beaulieu, F-35042 Rennes, Université Européenne de Bretagne, France* {Pei-yu.li, adrien.delaye, eric.anquetil}@irisa.fr

Abstract. We present here the Continuous Marking Menus, which help users learning a set of handwritten commands on a pen-based interface. The aim of this paper is to experimentally attest the interest of this new type of menu by evaluating its ability to help the learning of a set of gestures. We describe an experimental comparison on the task of learning a set of gestures with or without the help of Continuous Marking Menus, and we conclude that with the help of Continuous Marking Menus, people learn more easily the gestures.

The Ponzo Illusion affects movement characteristics in memory-guided target aiming movements. Mitchell G. LONGSTAFF, Matthew ISAAC, *Southern Cross University, Discipline of Psychology, Hogbin Drive, Coffs Harbour, NSW 2450, AUSTRALIA* {Mitchell.longstaff@scu.edu.au}

Abstract. When performing aiming movements we are typically accurate even when features of a target or its context result in us perceiving the movement requirements to be different to the actual requirements. However, some research suggests that our action system can be fooled. In the current study, 12 participants performed aiming movements with a stylus on a digitizer to round or elliptical targets, with or without a Ponzo Illusion as a background context. The movements were performed to remembered targets, with the target and background either disappearing immediately prior to the movement commencing, or after a 2000ms delay. In accordance with Fitts' Law, the participants decreased their movement time to larger targets. They also decreased their MT for targets in the illusion condition, suggesting that they perceived the target to be larger than it was (i.e. the Ponzo Illusion) and acted accordingly. Participants used greater movement amplitude in the illusion condition. This suggests in the illusion condition they perceived the targets to be further away than they were. The 2000ms delay did not change the pattern of results. It was concluded that the Ponzo Illusion resulted in the participants planning and performing movements according to the perceived rather than actual target characteristics.

EXHIBITIONS AND CONTRIBUTED POSTERS

The IGS Board would like to thank the support of the following EXHIBITORS:

Brain Vision LCC (http://www.brainvision.com): Full-service solutions for neurophysiological research including EEG/ERP soft- & hardware, EEG and fMRI compatible equipment, stimulation devices and accessories. Patrick Blitz (Morrisville, USA)

g.tec Medical Engineering (http://www.gtec.at): g.tec developed the first commercially available BCI system in 1999 and now sells this system in more than 60 countries worldwide. Our products work with all major BCI approaches (motor imagery, P300, SSVEP and slow cortical potentials), so you can start BCI research within a few hours. Christoff GUGER (Graz, Austria). As part of the exhibition, GTECH will present a brain-computer interface (BCI) workshop on June 15th 13:30-15:30. Pre-registration (indicate preferred date) is required. Please see: http://www.gtec.at/News-Events/Workshops/BCI-Workshop-in-Cancun-Mexico.

Quasar (http://www.quasarusa.com/). QUASAR is a leader in non-invasive physiological signal monitoring. Their easy-to-use wireless Dry Sensor Interface (DSI) EEG headset and ECG belt systems available for your research applications. For more information on QUASAR technology or to contact them, visit www.quasarusa.com

POSTERS

Prediction of Psychophysical Laws with the Beta-Elliptic Model. Hala BEZINE and Adel M. ALIMI, Research Group on Intelligent Machines, National School of Engineers of Sfax, BP. W, 3038, Sfax, Tunisia {Hala.Bezine, Adel.Alimi}@ieee.org

Abstract. A few years ago, a new way, for understanding the inherent mechanisms that governs handwriting movement generation, was proposed. This latter model is based on the Beta function to describe the velocity profiles with five parameters and the elliptic equation that characterizes the shape of the resulting trajectory with five parameters also. The overall approach is based upon the assumption that complex human movements can be segmented into basic and simple strokes. This paper explores the relation between the dynamics and the shape of a handwriting movement. This relation is implicitly expressed in the Beta-elliptic model. By means of numerical equations, reasons for the appraisal of the Beta-elliptic model have been demonstrated. It has been shown that an elliptic trajectory leads to a velocity signal that can be fitted with a Beta profile. A second finding resulting from the present study is that the Beta-elliptic model is able to explain several observations and psychophysical laws such us the Isochrony principle, which link the kinematics of handwriting movement with the handwriting trajectory.

Analysis of Shorthand Alphabets in Pen-Centric Handwriting Interfaces. Charles C. TAPPERT and Sung-Hyuk CHA, *Computer Science Department, Pace University, Pleasantville, NY 10570, USA* {ctappert, scha}@pace.edu

Abstract. Famous writers throughout history have preferred and effectively used shorthand – Cicero's orations, Martin Luther's sermons, and Shakespeare's and George Bernard Shaw's plays were all written in a style of shorthand. This paper analyzes and compares shorthand alphabets for pen-centric handwriting interfaces.

Surprising Power of Local Features for Automated Signature Verification. Marcus LIWICKI, Muhammad Imran Malik, *German Research Center for Artificial Intelligence (DFKI) Trippstadter Str. 122*, *67663 Kaiserslautern, Germany* {*firstname.lastname*}@*dfki.de*

Abstract. In this paper we report on the results of an automatic signature verification system on data of the 'ICFHR 2010 4NSigComp' forensic signature verification competition. The goal of this competition was to estimate the performance of automated systems in detecting skilled forgeries from genuine signatures of a reference writer. Unlike previous research in the field of signature verification, where the task was generally to separate the genuine signatures from the forged ones, another equally important category of forgery, namely the disguised signatures was also addressed in this competition. A disguised signature is a signature written by the authentic author but with the intention of possible denial at a later date. The system described in this paper did not participate in the competition, since it has been originally designed by the organizers of the competition. As an interesting outcome of the experiments, the system could achieve better equal error rates that any of the other submitted systems. The somewhat surprising fact is that the system has not been adapted to detect disguised signatures; it has originally been created for the task of detecting simulated and authentic signatures. We strongly

believe that the main reason for the good performance is the difference that our system is relying on local features.

Learning an Indian Abiguda Script : Bangla. Bidyut B Chaudhuri, *Indian Statistical Institute, 203 B T Road, Kolkata -700108, KOLKATA, INDIA* {bbcisical@gmail.com}

Abstract: Bangla is the principal language and script of West Bengal (India) and Bangladesh, catering about 230 million people of South-east Asia. This script, derived from ancient *Brahmi,* is almost 1000 years old and its modern form came into existence in 17-th century AD. It belongs to Abiguda or Alpha-syllabary class of scripts, where apart from the alphabet consisting of vowels and consonants, formation of (a) orthosyllable or *Akshara* of consonant with vowel modifier signs and (b) conjuncts of two, three or four consonants as well as their akshara formation, make a few thousand compound shapes. The problem of remembering, reading and writing i.e. learning to use Bangla script can be used as a case study for learning problems of abiguda class of scripts prevalent in South East Asia. Among early works on Indian scripts, some studies on Hindi word recognition have been done by Vaid and Gupta (2002). Also, Karanth et al (2004) worked on Orthography and reading speed for Kannada script. To the best of our knowledge, this is the first work on Bangla, used by 250 million people in India and Bangladesh.

Evaluation of a Remedial Handwriting Program for Print Legibility. Catherine, CANDLER, Jan McCLESKEY. *School of Occupational Therapy, Texas Woman's University, 8194 Walnut Hill Lane, Dallas, Texas 75231 USA* and *The Handwriting Clinic, 1506 Capitol Avenue, Plano, Texas 75074 USA* {CCandler@twu.edu, Jan@thehandwritingclinic.com}

Abstract. The purpose of this study was the evaluation of a handwriting program designed to improve the legibility of non-proficient writers who have mastered the basics of visual memory and letter formation. The *One Hour to Legibility* program provides remedial handwriting instruction with emphasis on spatial organization characteristics, specifically letter sizing, and on an error detection approach to good letter formation without attention to stroke sequencing. A single group repeated measures design was employed for 26 children, mean age 9 years 2 months at *The Handwriting Clinic* in Plano, Texas. Results showed positive changes for measures of individual letter legibility, alignment, sizing, and overall legibility. Follow up performance suggested spatial organization contributed more to overall legibility than letter formation for this group of participants.

Procedural Description of drawing activity. Ney RENAU-FERRER, Céline REMI, *LAMIA Laboratory, University Antilles Guyane*, *97110, Point à Pitre, GUADELOUPE* {nrenaufe, cremi}@univ-ag.fr

Abstract. This article handles the problem of the automatic analysis of geometrical sketches recorded online. Such sketches can be analyzed according to several points of view. As for offline recording, we can try to recognize the produced shape. Moreover, online recording allows other kind of analysis like the one of the subject's procedure during the production of sketches. We propose a method for automatically extract and describe such behavior. A measure for the estimation of the dissimilarity of procedures is also defined. Then we present the results of preliminary simple tests made with these methods.

Temporal and Spatial Differences Between Online and Offline Signatures. Heidi H. HARRALSON[a], Hans-Leo TEULINGS[b], and Larry S. MILLER[c, a] *East Tennessee State University, Johnson City, TN, USA,* [b] *NeuroScript, Tempe, AZ, USA,* [c] *East Tennessee State University, Johnson City, TN, USA,* Spectrum008@aol.com, hlteulings@neuroscript.net, millerls@etsu.edu

Abstract. Online electronically captured signatures are compared to offline paper and ink signatures to determine differences between the two conditions. Sixteen subjects wrote signatures on a digital tablet using three different writing implements: 1) ink ballpoint pen on paper; 2) noninк digital tablet pen; and 3) mouse. Significant differences in duration were found between each of the three conditions. Duration was slower with the noninking pen and slowest with the mouse. Vertical size increased with the mouse. Individual results showed an increase in intra-writer variability in the non-ink and mouse conditions. Results suggest Forensic Document Examiners need to carefully evaluate limitations when comparing online and offline signatures.

Adaptive Inverse Modelling in the Frontal Mirror Neuron System for Action Imitation. Hyuk OH, Rodolphe J. GENTILI and José L. CONTRERAS-VIDAL, *Neuroscience and Cognitive Science Program,* b *Department of Kinesiology, The Fischell Department of Bioengineering, University of Maryland, College Park, MD 20742, USA,* {hyukoh, rodolphe, pepeum}@umd.edu

Abstract. It has been suggested that the human mirror neuron system can be described as a set of two main components along with an additional assisting component. Namely, the two core components are located in the inferior frontal cortex (i.e., frontal mirror neuron system) and the rostral part of the posterior parietal cortex (i.e., parietal mirror neuron system). The third assisting component, named the mirror-like system, has been identified in the superior temporal sulcus. During imitation of an observed action, the functional relationship between these structures can be modelled with the classical computational concepts of internal models. Based on this biologically plausible framework, we propose that the frontal and parietal mirror neuron systems work as an inverse and a forward model, respectively. Our results revealed that the inverse model can successfully and progressively learn to imitate a reaching/grasping action that was previously observed.

Are dysgraphic children really slower than proficient handwriters? Vietminh PAZ VILLAGRAN [a], Jean-Claude GILHODES, Lise ALARY [b], Camille ANTONI [b], Elisabeth CHARBONNIER [b] and Jean-Luc VELAY [a]**;** a- Mediterranean Institute for Cognitive Neurosciences, (UMR CNRS 6193)**,** 31 chemin Joseph Aiguier, 13402, Marseille cedex 20, France**,** b- Speech Therapist School, Medical Faculty, Marseilles, France {vietminh.paz, velay@incm.cnrs-mrs.fr}

Abstract. Dysgraphia is a writing dysfunction characterized by poor legibility and a slower performance time in handwriting. This disturbance during childhood results in a failure of children's academic development. Performance time, path trajectory length and writing velocity are spatiotemporal variables that were used as indicators to typify children's handwriting. In this study we compared these variables between proficient handwriting children and dysgraphic children under two writing speeds conditions: normal writing speed and fast speed. Results showed that both groups accelerate from normal to fast speed in the same manner. No difference in writing velocity was observed. This study suggests that dysgraphic children wrote larger and consequently required more time than proficient children to write the same word. Nevertheless handwriting velocity is the same for all children.

Biological-Inspired Approach to Detect Contours from Noisy Images. Carlos A. DIAZ-HERNANDEZ, José L. MUÑOZ-LOZANO and Juan LOPEZ-CORONADO**,** *Departamento de Ingeniería de Sistemas y Automática, Universidad Politécnica de Cartagena, 30202, Cartagena, SPAIN* ca.al.di.he@gmail.com, {joselu.mlozano, jl.coronado}@upct.es

Abstract. In this article we address the problem of boundary detection by applying ideas and approaches from biological vision. We implement a simple and efficient architecture for the accurate detection of contours. Obtained contours will be used for incremental reconstruction of

complex scenes and hand-written recognition. The obtained information from the scene can be applied later making decision in path-planning or task-planning for mobile robots in a cluttered scene. We present here some results of boundary detection in representative images from target scenes in our robotic applications. The results are promising.

Forensic examination of the writing of a man with multiple personalities. Bonnie SCHWID, BS, B-BFDE [a], *Anagraphics, LLC, 1009 W. Glen Oaks Lane #207*, *53092, Mequon, WI, USA* {bschwid@anagraphics.com}; Hans-Leo TEULINGS, NeuroScript, LLC, Tempe, AZ, USA {hlteulings@neuroscript.net }

Abstract. This is a case study of a person with Multiple Personality Disorder (MPD), presently known as Dissociative Identity Disorder (DID). Handwriting was collected over a period of 17 years. Little is known about the differences in handwriting movements between the various personalities within the same person, especially when recording handwriting using a writing tablet.

A neural network model for complex handwriting generation movements. Mahmoud LTAIEF, Hala BEZINE and Adel M.ALIMI, *Research Group on Intelligent Machines (REGIM), National School of Engineers of Sfax, BP. W, 3038, Sfax, TUNISIA,* {mahmoud.ltaief, hala.bezine, Adel.Alimi}@ieee.org.

Abstract. A neural network model for handwritten script generation is proposed, in which curvilinear velocity signals are approximated by the Beta profiles. For each Beta profile we associate an elliptic arc to fit the initial stroke in the trajectory domain. The network architecture consists of an input layer which uploads the set of Beta-elliptic characteristics as input, hidden layers and the output layer where script coordinates X(t) and Y(t) are estimated. A separate timing network prepares the input data. This latter involves the time index starting time of each simple stroke for an appropriate handwriting movement. The experiments showed that the neural network model could be applied for the case of Latin handwriting scripts as well as Arabic handwriting scripts. New ways are proposed for the application of the neural network model such as: generation of complex handwriting movements, shape and character recognition, etc.