

## DEVELOPMENT AND APPLICATIONS OF BCI AT SANTA LUCIA FOUNDATION

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The Santa Lucia Foundation is a renowned hospital for the neuro-motor rehabilitation of patients suffering from different diseases (stroke, amputation, paraplegia, etc). Since the beginning of its activities, in addition to the clinical routine a great deal of scientific research work on the themes of neuroscience was carried out, also in cooperation with Italian and foreign Universities. For the last 10 years, the Santa Lucia Foundation was recognized “IRCCS” (Scientific Institute for Research, Hospitalization and Health Care) by the Italian Government.

As for clinical activity, the center admits about 2000 patients per year, mostly affected by neurological diseases, caused by either cerebrovascular or degenerative or post-traumatic injuries. The treatment of these patients comprises motor rehabilitation (functional recovery and development of compensation strategies) or cognitive rehabilitation.

As a research center, the scientific interest is focused on themes regarding neurological and motor rehabilitation, spanning from neurophysiology and neuroimages to experimental neuropharmacology and kinematics of movement. The scientific productivity benefits from the cooperations that the Santa Lucia Foundation has with national and international centers. This effort produces about 100 publications per year on scientific journals.

In this context, the research on Brain-Computer Interfaces is supported by a group of researchers with different skills, both on the neurological side and on the bioengineering side. All researchers have previous experience in the field of EEG acquisition and analysis in the framework of neurophysiological research.

During the years 1998-2001, the group participated in an important project funded by the European Commission named ABI (Adaptive Brain Interfaces). The main achievements of the project were: (i) the development of effective EEG classification algorithms, which brought to several publications on scientific papers and presentations at international meetings; (ii) the availability of a prototype of portable BCI; (iii) a large resonance in the media (e.g. more than 100 interviews and articles on newspapers and magazines) and in the European Commission (e.g. selection of the project as finalist of the Descartes Project, the major European science prize for outstanding collaborative research in any scientific field).

The current version of our Brain Computer Interface is based on: (i) the acquisition of eight EEG channels placed on the fronto-centro-parietal regions of the scalp; (ii) the extraction (twice a second) of spectral features, in the band 8-30 Hz; (iii) the classification through a local neural classifier, based on the Mahalanobis distance of incoming features vectors from given prototypes. The prototypes were obtained using the expectation maximization framework on samples of the features vector used as training set.

The current research efforts are aimed at three objectives:

- (i) improving portability and effectiveness of the working prototype. This research benefits from the collaboration with the group at Tor Vergata University (Rome) with its engineering competence and has already produced a new promising type of quadratic classifier;
- (ii) adaptation and development of applications to use the current prototype as an aid for disabled people. This research line is funded by the Italian National Research Council and is carried on in cooperation with other groups from the Universities of Rome. In this research line we benefit from the environment provided by the hospital and the established competence in the care-giving of the many patients;
- (iii) application of the technologies developed in the BCI research to the studies on cerebral plasticity. We expect to provide evidence for a potential application of the BCI area into the cognitive/motor retraining processes after focal brain injury, to implement future rehabilitation strategy.