

Home-based treatment of autism

Much can still be done to improve autism treatment besides finding a cure. The MICHELANGELO project, which ended in March, has developed a set of technologies for personalised, home-based behaviour monitoring and treatment of patients.



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For a child suffering from autism, a treatment involving constant back and forth journeys between home and hospital can be difficult to cope with. But this also has many other shortcomings: it marginalises the potential role of parents in helping their children, fails to reflect real life behaviours, is not intensive enough and fails to consider the specificities of each patient. Last but not least, it is a major financial burden for society as the number of children diagnosed with autism keeps

increasing each year and a cure has yet to be discovered.

With all these problems in mind, the team in the EU-backed project MICHELANGELO (Patient-centric model for remote management, treatment and rehabilitation of autistic children) has spent the past five years working on home-based solutions for assessing and treating autism outside the clinical environment. The project has developed: a range of pervasive sensor-based technologies to perform physiological measurements such as heart rate, sweat index and body temperature; camera-based systems to monitor observable behaviours and record brain responses to natural environment stimuli; and algorithms allowing for the characterisation of stimulus-specific brainwave anomalies. These technologies will allow for personalised treatment and, just as importantly, will give parents the role of co-therapist, helping them to better understand their child and provide them with appropriate care.

Silvio Bonfiglio is the coordinator of the MICHELANGELO project, a role he was given due to his considerable experience in medical imaging, interactive solutions,

user interfaces, mobile point of care and e-health. He highlights the main results of the project and expands on his plans for bringing it to patients by 2017.

What are the main objectives of the project?

We intend to move the treatment of children with 'Autistic spectrum disorders' (ASD) from the clinical setting to the 'more natural' home environment. There, newly-designed and non-obtrusive techniques will be used to ensure a timely assessment of the evolution of the disease as well as the prompt adaptation to and personalisation of the treatment.

These include the use and contribution to the advance of new technologies such as computer vision, unobtrusive and wearable 'electro-encephalogram' (EEG) and 'electro-cardiogram' (ECG) monitoring, eye-tracking, robotics, signal and image processing, etc.

Secondly, the project intends to contribute to research in ASD which is still in its infancy, and to open new opportunities in the field of 'personalized treatments'.

What led you to do research in this area?

According to recent studies, the prevalence of autism is increasing — in Europe, 1 case for every 86 children. This trend has a considerable social and economic impact, with heavy consequences affecting not only the patient but all family members. The average lifetime cost for a person with low functioning autism is estimated to range from EUR 5 to 6 million.

Our project builds upon the scientific acknowledgement that the efficiency of autism treatment could be greatly enhanced through the likes of early diagnosis and a timely and intensive educational programme carried out when the brain plasticity of the child is maximal, as well as the design and provision of personalised intervention protocols. Our technology is expected to contribute to the realization and success of this strategy.

What are, according to you, the main benefits of a home-based intervention compared to in-lab experiments?

By moving autism treatment from the clinical setting to home, the MICHELANGELO approach will help overcome the main weaknesses of current ASD management practices. We know for a fact: that the 'artificial context' of the lab-based environment generates results that do not reflect behaviours in real life; that the lack of intensiveness of the treatment — only 1 or 2 therapeutic sessions a week — limits beneficial effects; and that it entails a poor personalization of the intervention protocol.

To give you an example, a brain map obtained through an electro-encephalogram (a quantitative QEEG analysis) could give useful information. Unfortunately, the invasiveness of the currently-used systems (dense-array EEG systems) induces both

systematic and non-systematic biases towards the experimental outcome, eluding the actual nature of the brainwave behaviour and connectivity. MICHELANGELO minimises these biases and modulation effects by making the recording system pervasive in nature so that the patients becomes 'unaware' of its presence. In the same way, a set of wearable and non-invasive sensors facilitates the monitoring of ECG parameters, thereby allowing the timely detection of problematic behavioural and emotional changes in the child (e.g. anxiety status, lack of engagement/attention, etc.). In that respect, the project's challenge was to achieve the best compromise between unobtrusiveness and measurement accuracy; it was obtained through novel algorithms for effective artefact suppression and intelligent solutions of data processing, fusion and feature extraction. Furthermore, the home-based intervention promises to improve the overall quality of care and certainly the quality of life of the patients and their families (less need to travel to specialised centres, fewer lost working hours, etc.).

How does the MICHELANGELO system work exactly?

MICHELANGELO proposes an approach that includes five main steps: the characterisation of the autistic child in a controlled environment at the medical centre (the 'MICHELANGELO room'); the design of a patient-centric intervention protocol based on serious games; therapeutic intervention at home through physiological sensors; adaptation of the therapeutic intervention on the basis of gathered information (remote meetings and training); and a periodic assessment taking place at the hospital, with advanced lab examinations relying on new methods developed under the project.

You claim that this method will be more cost-effective than in-lab experiments. How so?

The MICHELANGELO approach combines intensiveness of the treatment — it is no longer limited to a few hours a week at the therapist's office or at the hospital — with cost effectiveness thanks to automation and minimal, seamless intervention by the doctor.

Another key benefit arises from early therapeutic interventions which also result in cost saving. As observed by the European Autism Information System, 'the later the intervention in the affected child's life, the greater the time and costs involved in providing healthcare and support services.'

Finally — as already mentioned — the home-based approach has clear benefits for the families by reducing the frequency of travelling to external specialised centres and the number of lost working hours.

MICHELANGELO also offers a tool for better productivity and support to the medical professionals during the therapeutic sessions with the child at the medical centre.

What will be the role of parents in this setup?

By transferring the therapeutic intervention from the hospital to the home, MICHELANGELO emphasises the role of the parents and educators and fosters the cooperation between them and the medical professionals. In the MICHELANGELO approach, they will act as 'co-therapists' and will participate in the care process.

One idea that stands out on the project website is the observation that each child is unique. How does your system take this uniqueness into account?

Indeed every child is 'unique with unique problems and needs'. So the treatment has to be tailored to this reality. As highlighted by some researchers, two people with the same age, gender, IQ, medication use and diagnosis may respond very differently to the same treatment.

Unfortunately there are still a lot of open questions pending since very little is known about how to individualise treatment protocols in ASD. MICHELANGELO proposes a quantitative way to assess the brain connectivity of a specific child while he/she is executing a task, to determine how the connectivity reacts to therapeutic intervention, and to define whether a personalised therapy can produce structural changes in the brain by removing or reducing connectivity weaknesses.

Another key point is that different children in fact have different attitudes, needs and reactions to the treatment. By monitoring their psychophysical parameters it could be feasible to adapt the treatment as much as possible to their needs, maximise the efficiency and minimize the possible drawbacks of therapy.

In the same way, we demonstrated in MICHELANGELO how autistic children and typically developing children have significantly different features extracted by the ECG signal, in the Time- and Frequency-Domain, at baseline and during a specific task. We developed a wearable, unobtrusive ECG monitoring platform by making the approach minimally invasive. This solution supports the therapists in the diagnosis of ASD and provides a very reliable and objective way to assess the psychophysiological state of the child and customise the treatment as much as possible.

When do you hope your technology to be made available to patients? Have you witnessed interest from potential partners yet?

The exploratory study executed under the project in France and Italy provided the proof of concept of the approach developed in MICHELANGELO. Now, more extended clinical studies will be needed to get a full medical validation, and at the same time further development activities have to be planned to refine and industrialise the solutions.

Considering these, we estimate that the market introduction of MICHELANGELO solutions can take place in two years from now, in 2017.

Therapists and clinicians from specialised medical centres have already shown interest in the novelty of both the approach as a whole and our ICT-based system,

unanimously acknowledging their benefits in terms of efficiency, more accurate diagnosis and assessment, and quality of care. The parents of the children participating in the exploratory study were equally interested, which is really positive.

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