

### Fiche de stage

**Sujet du stage : Explainable Multimodal Machine Learning for TECH-TOYS: application to Precision Medicine models of developmental disorders**

Encadrant·e : Mohamed Chetouani

Durée du stage : 5 à 6 mois

Niveau d'études souhaité : Master 2 / Ecole d'ingénieurs

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Date limite de dépôt de la candidature : 15/12/2021

### Description du stage

**Explainable Multimodal Machine Learning for TECH-TOYS: application to Precision Medicine models of developmental disorders**

#### Context:

Neurodevelopmental disorders (NDDs) are a group of frequent (1/10 children) sensori-motor, cognitive, communication, learning, behavioral disorders of multifactorial aetiology, with onset early in life but life-long consequences. Despite advances in our understanding of aetiology, diagnosis and start of intervention are often late (many months after onset of first clinical signs) and not based on quantitative data.

The PIROS team is engaged in the international TECH-TOYS project which aims to develop an innovative technological play setting (i.e., a gym equipped with a sensorized mat, a set of sensorized toys, wearable inertial movement units and cameras), suitable at infant's natural environment, to provide easy-to-handle quantitative measurements of infant's neurodevelopment and infant-caregiver interaction. Obtained data will provide a computational Precision Model for early detection of atypical features using digital biomarkers.

The study of digital biomarkers usually follows a retrospective methodology [Saint-Georges-2010]. Several infants are engaged in a protocol, and after diagnosis (around 3 years) clinicians are able to define control and pathological groups. Computational models could be employed to characterize and predict developmental disorders based on the analysis of such longitudinal data [Saint-Georges-2011].

Sous la co-tutelle de :

### Objectives:

In this project, we investigate developmental disorders such as autism spectrum disorders. The data collected (during the 3 years) are then employed to develop predictive models of the pathology.

The objective of this work is to develop multimodal machine learning techniques to identify digital biomarkers grounded in Explainable Artificial Intelligence [Arrieta-2020; Walkotter-2021]. We will take advantage of a combination of previous big data already acquired (see CareToy project <http://www.carettoy.eu>) with new ones collected prospectively during the project.

This work will exploit methodologies and models of human-robot interaction and machine learning. We will use data collected in previous projects to develop predictive models of developmental disorders using multimodal signals. In addition to the model, we will work on the design of TECH-TOYS device. The work will include collaborations with TECH-TOYS partners in Italy, Turkey and Germany in order to address clinical, ethical, legal as well as scientific issues raised by the project.

The main steps are:

- Design a study for the prediction of developmental disorders based on CareToy data.
- Selection of relevant multimodal signals (sound, accelerometers, video).
- Development of machine learning based models able to predict developmental disorders.
- Define requirements for a future TECH-TOYS device

### Skills: Python, Machine Learning, and Robotics

### References:

[Arrieta- 2020] Arrieta, A.B., Diaz-Rodriguez, N., Ser, J.D., Bennetot, A., Tabik, S., Barbado, A., Garcia, S., Gil-L'opez, S., Molina, D., Benjamins, R., Chatila, R., & Herrera, F. (2020). Explainable Artificial Intelligence (XAI): Concepts, Taxonomies, Opportunities and Challenges toward Responsible AI. ArXiv, abs/1910.10045.

[Saint-Georges-2010] Saint-Georges, C., Cassel, R.S., Cohen, D., Chetouani, M., Laznik, M.C., Maestro, S., & Muratori, F. (2010). What studies of family home movies can teach us about autistic infants: A literature review. *Research in Autism Spectrum Disorders*, 4, 355-366.

[Saint-Georges-2011] Saint-Georges, C., Mahdhaoui, A., Chetouani, M., Cassel, R., Laznik, M.C. et al. (2011) Do Parents Recognize Autistic Deviant Behavior Long before Diagnosis? Taking into Account Interaction Using Computational Methods. *PLoS ONE*, Public Library of Science, 2011, 6 (7), pp.e22393. ([10.1371/journal.pone.0022393](https://doi.org/10.1371/journal.pone.0022393)). ([hal-02423441](https://hal.archives-ouvertes.fr/hal-02423441))

[Walkotter-2021] Walkötter, S., Tulli, S., Castellano, G., Paiva, A. and Chetouani, M. (2021). Explainable Embodied Agents Through Social Cues: A Review. *ACM J. Hum.-Robot Interact.* 10, 3, Article 27 (July 2021), 24 pages. DOI:<https://doi.org/10.1145/3457188>