Development of Robot-enhanced Therapy for Children with Autism Spectrum Disorders

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DREAM
Development of Robot-enhanced Therapy for Children with Autism Spectrum Disorders

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D3.4.4 System Integration Progress Report

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

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Executive Summary

Deliverable D3.4 is an annual progress report on the integration of the software developed in work packages WP4, WP5, and WP6. This is the Month 48 progress report. We left year three of the project with a complete system that just came together by the end of February 2017. From a software engineering point of view, this forth year has focused on software maintenance, bug fixing and system tuning.

WP3 has also focused on the open source release of the project. As presented at the P3 review. the concortium agreed to release the full DREAM system as open source on GitHub. This release took place at December 20, comprising 15 system components and an additional 25 test components.

Since no newly developed system components has been produced during this period, the need for system integration and QA procedures has decreased. Instead, WP3 has fulfilled a supporting role in the project and in addition to system maintenance helped with data extraction and analysis, mainly for WP2 and WP5. One utility application, *User Data Export*, has gone through extensive updates implementing automatic generation of Elan (eaf) files that allows detailed traceability of all automatic assessment.

Two integration meetings took place during period four. The first, co-arranged with the P3 review, took place at Babe-Bolyai University and focused on system tuning and adjustments for the continued evaluations within WP2. The second took place at the University of Plymouth, January 23 2018, focusing on data analysis and integration with WP5.

Last, but not least, three new PhD students entered the team during period four. Although not solely connected to WP3, their role in the project and plans for the final period is briefly presented here.

Principal Contributors

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Revision History

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1 Introduction

We came into this fourth period of the project with a complete system that just got up and running during February and March, 2017. The system had at this point undergone the QA and integration procedure adopted within the project and was, although far from perfect, in a good enough state to be useful in therapy. Since then, it's been used to carry out more than 500 interventions with 74 children, comprising more than 3000 interaction sessions.

Sec. 2 summarizes WP3 activity in terms of system integration and maintenance during period four. Since the third and largest evaluation of the system started already in March 2017, and is still on-going, we have avoided any dramatic changes or updates to the system this period. Instead, larger efforts have been put into an open source release of the system, presented in Sec. 3. WP3 has also taken a supportive role in the project, helping with extraction and analysis of system data. This work has resulted in several updates to the utilities developed and used within the project, presented in Sec. 4.

As discussed in Sec. 5, two developer meetings held during the past year. The first, co-arranged with the P3 review, took place at Babe-Bolyai University and focused on system tuning and adjustments for the continued evaluations within WP2. The second took place at the University of Plymouth, January 23 2018, focusing on data analysis and integration with WP5.

The past year also meant changes in the staff working within WP3. In contrast to the last period when we saw David Vernon leaving the project, we now have a much more positive changes in the form of three new team members. First out was PhD student Julia Rosén, starting September 10th, 2017, associated with the University of Skövde. Shortly after, from October 1st, 2017, PhD student Madeleine Bartlett began her studies at the University of Plymouth. Finally, PhD student Vipul Nair joined in November 2017, associated with the University of Skövdex.

2 System maintenance

The forth period comprise smaller fixes and adjustments to several system components that were already integrated during earlier periods. The largest new component developed during this period is *sensoryAnalysisOffline* which mirrors the *sensoryAnalysis* component in terms of output data, but takes input from recorded interventions rather than a live sensor data from the intervention table. This off-line component has proven to be critical for analysis purposes.

Two important system issues were identified during the evaluation running as part of WP2. Firstly, occasional crashes were experienced and developers PORT and HIS, with support from other partners, got together trying to sort out these issues. After extensive system testing on all three sites (UBB, PORT, and HIS), the problem was identified as a hardware error causing bad contact between the USB controllers and the power supply, resulting in random system crashes. The large 2017 evaluation has covered several cities in Romania and the issue appeared during transport of the system between cities. This problem was finally fixed after several meetings and discussions among the three sites.

The other issue that came up during period four concerned the results. The therapists noticed that the system on rare cases reported an incorrect number of child performances for a recorded session. This was seen as a serious issue since it affected the trustworthiness of the results. This issue were mainly analyzed by HIS and PLYM and after extensive work two independent bugs were identified, affecting the scores. When the automatic assessment of the system failed and the supervising therapist intervened to correct the system, she pressed a button in the SPARC GUI to indicate the correct response. If the therapist by mistake pressed this button twice, two scores were recorded in the user

model. This created duplicates that lead to wrong results being reported in the *User Data Export* (c.f., D3.4.3, Sec. 5.3). Simultaneously, the session time window recorded in the user model was, in rare cases, too short, excluding performances that happened late in a session. The cause was traced to come from a specific configuration of the interaction scripts.

Both problems with the results report were solved by re-generating Elan files from the system logs. These use of automatically generated Elan files allows automatic child assessments to be manually verified against the video recordings and at the same time constitute basis for the complete evaluation statistics used in WP2. This process is described in detail in Sec. 4.

3 Open source release

An important task for WP3 during this forth year of the project has been to prepare an open-source release of the DREAM system. A first release was made using GitHub, `https://github.com/DREAM2020/dream`, in December 2017. The software has been licensed under GNU GPL, v. 3 and comprising 13 system components along with test components and documentation.

In its current form, the system requires specific hardware in the form of both a Nao robot, Kinect cameras, USB controllers, and the intervention table. Additionally, it requires manual calibration in order to work well. In sum, it would take a third partly significant effort to set up the full DREAM system again, especially without support from the developers within DREAM, and we are not aware of any third party who've tried to do this as of today. Instead, we believe that this open source release gives the possibility for the RET community, and other developers, to look up details on how various parts of the software were implemented. Several of the components can be executed individually, or in combination with provided driver/stub components, removing many hardware dependencies.

4 Data analysis and utilities

D3.4.2 presents two utility applications, *componentChecker* and *yarpGenerator*. D4.3.3 extended the set of utility applications with *DREAM Boxology*, *Script Generator*, *User Data Export*, and *User Model Creator*. Here, we do not introduce any completely new utilities. Instead, P4 has involved extensive work on data analysis, including updates and re-writes of the *User Data Export* tool.

The DREAM system stores information recorded during interventions in three forms. First, sensor data, primarily RGB and RGBD video feeds, are stored as a collective set of recordings. Secondly, communication between components in the system, utilizing the YARP PCP protocol, are logged to traditonal text-based log files. Finally, an XML-based user model stores information about users, interventions, and performances for easy access to the most important outcomes. As discussed in Sec. 2, two issues with the user model were identified, causing a small proportion of the performances in the User Model to be incorrect.

The former version of *User Data Export* generated an Excel sheet listing outcomes, i.e., the number of correct and incorrect performances on each task during intervention, following the ABA protocol. While this provided a comprehensive overview of all results from the evaluation, it abstracted away information about when and how a specific performance was assessed.

In order to tackle the issue with the incorrect performances in the user model, *User Data Export* was updated to integrate results from all three sources listed above and to output an intermediate level of results in the form of Elan files. The Elan annotation software[1] has been used extensively through

[1]ELAN is a open-source tool for the creation of complex annotations on video. `https://tla.mpi.nl/tools/`

the DREAM for manually annotating intervention recordings. Manual annotation of video is very time-consuming and an important purpose of the system recordings has been to automate this tedious work, and also to increase the quality of annotations.

With the new version of *User Data Export*, the system video recordings are automatically converted into a format suitable for Elan and associated with corresponding performance measures recorded in log-files and the user-model. By combining all three sources of information, we were able to reconstruct the exact time for each performance which in turn allowed automatic detection of duplicates and inclusion of late performances, solving both problems listed in Sec. 2. The results are stored in Elan (eaf) files for manual inspection and traceability. The eaf files are then converted into a summary report (Excel sheet) which provides a similar overview as the original *User Data Export*, constituting a good basis for the statistical analysis.

At the time of writing, this work is still on going, in parallel with the final evaluation in WP2.

5 Integration meetings

During the past year, two physical meetings have played a key role discussing system updates and resolving identified system issues (c.f., Sec. 2). In addition, weekly interactions over Skype and email have continued to strengthen interaction in the interim of the three larger meetings listed below.

5.1 UBB update meeting

September 25-26, 2017, a developers meeting was held at the Babe-Bolyai University, co-arranged with the P3 review. In addition to the preparations of the review demo, the meeting focused on planning for system updates, improving performance of the automatic child assessment.

5.2 Integration meeting at PLYM

January 23, 2018, an integration meeting were held at Plymouth University. The meeting focused on links between WP3 and WP5 concerning development and analysis of child assessment methods, but also constituted a time to introduce the new PhD students, Julia Rosén (HIS), Vipul Nair (HIS), and Madeleine Bartlett (PLYM) and their work in WP3, WP5, and WP7.

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