INTERACT – Interactive Manual Assembly Operations for the Human-Centered Workplaces of the Future

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Summary:

Deliverable D4.3.2 created in Task 4.3 – *"Initial prototype for recognition and classification of executed assembly operations"*

This report provides an evaluation of the first prototype that implements the motion recognition and classification of human work activities. More specifically, this report shows the first evaluation results of the motion recognition algorithm presented in D4.3.1.

Contents

1. INTRODUCTION

During the development of the Motions Recognition Algorithm (MRA), experiments were constantly performed in order to configure the rules of the algorithm. At M18 of the INTERACT project, 40 tests were conducted with four people who were not familiar with the developments, in order to obtain a preliminary evaluation of the algorithm. The aim of the experiments was the evaluation of the algorithm using two criteria:

- The success of recognising an observed motion
- The difference in start and stop frames between observed and actual motions

The second criterion is important due to the motion related information identification. Since the purpose of the algorithm is to recognise motions and store specific information about them semantically, it is important that this information is correct. The closer the recognised start and end frames are to the observed ones, the more accurate the information acquired are.

In the next sections the setup of the test sessions is described and then the results of the evaluation are provided. Finally, a discussion on the improvements of the algorithm, towards the final prototype and first validation, are provided.

2. SETUP OF TEST SESSIONS

The MRA is currently implemented as a desktop application, with a Graphical User Interface (GUI) for the import of sensor data and the export of the recognized Motion Elements (MEs). The user has the ability to review the results of the algorithm using the same GUI (Figure 1). Currently the algorithm requires approximately 5-8 seconds for processing a 60 seconds MoCap session, recognizing the performed motions and calculating their parameters.

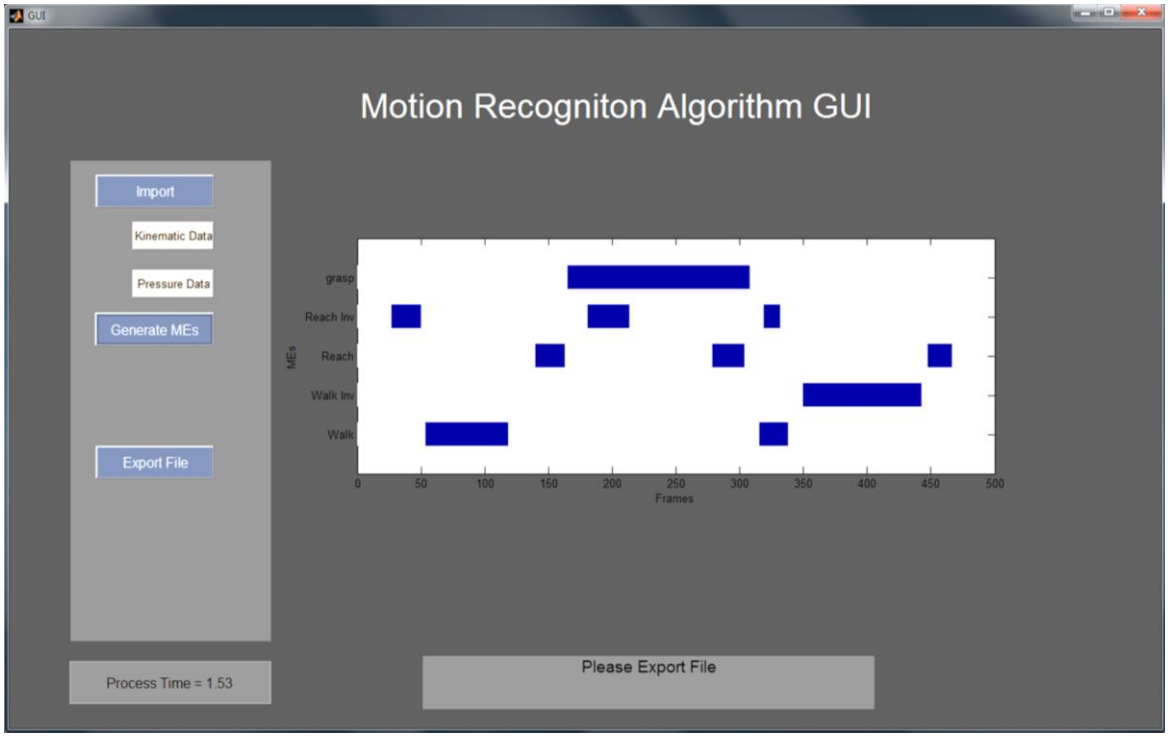

Figure 1: GUI of the MRA.

The experiments regarding the evaluation of the MRA were performed in a space of approximately 10 square meters. The space was arranged to have two stools of different heights, where the actors would pick and transfer an object from one to the other.

More specifically, the stools had heights of 110 cm and 70 cm. A cup like object was placed on one stool and the actor had to perform the following tasks:

1. Walk towards the stool that the object is placed on
2. Pick the object
3. Carry the object to the other stool
4. Place the object on the other stool
5. Return to starting point

The stools were placed in different positions based on two setups (Figure 2).

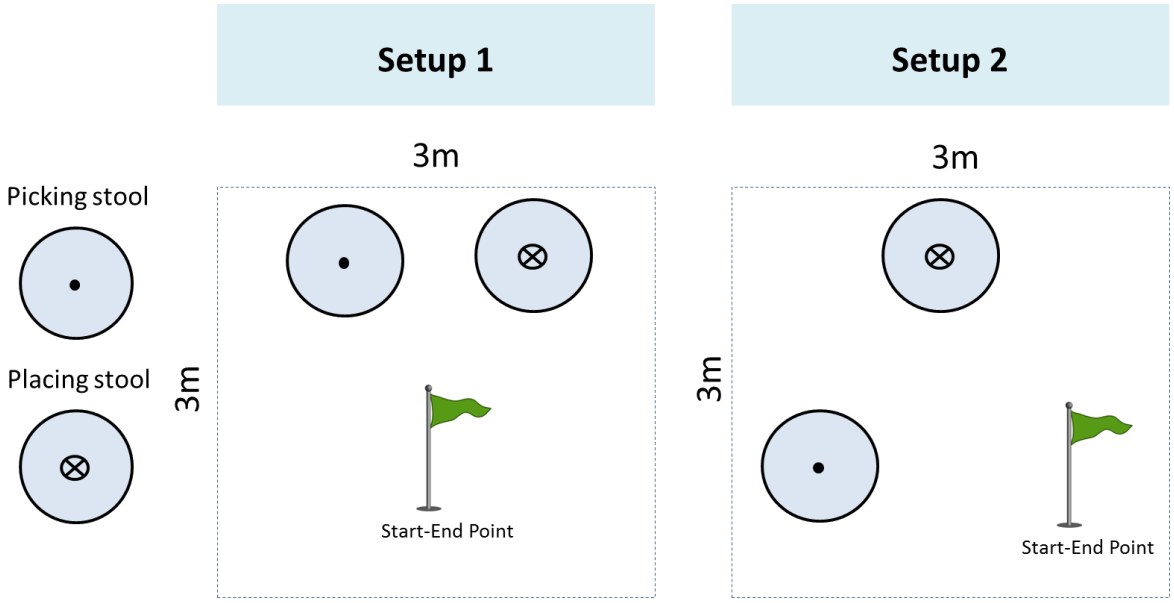

Figure 2: Tests' special and objects' setup.

Although the stools were place in order for the actors to perform a sidestep (Setup 1), they were not instructed to do so, resulting in different combinations of motions in the different takes. For tracking the motions two Kinect v2 were used as well as one glove containing pressure sensors (Figure 3).

Figure 3: Sensors used during the tests.

The actors who participated were two males and two females, with different heights, as can be seen below (Figure 4), with the following characteristics:

Table 1: Actors' physical characteristics.

Actor	Sex	Age (yrs)	Height (cm)	Weight (kg)
Male_1	M	26	170	74
Female_1	F	23	160	52
Male_2	M	22	190	105
Female_2	F	24	172	59

Figure 4: Actors who participated in the tests.

3. TESTS RESULTS

For each scenario, the actors performed the motions five times, resulting in 40 takes in total. The following table shows the results for each actor, in terms of recognition of the motions.

Table 2: Results of recognising the performed motions.

	Walk	Walk Inv.	Reach	Reach Inv.	Sidestep	Grasp
Male_1	15/15	10/10	20/20	20/20	5/7	10/10
Female_1	15/15	10/10	19/20	15/20	7/7	10/10
Male_2	14/14	10/10	20/20	18/20	6/8	10/10
Female_2	17/18	9/9	20/20	20/20	4/6	10/10
Total	61/62	39/39	79/80	72/80	22/28	40/40

Although the algorithm proved to be adequate for recognising motions such as Walking, two of the motions were not recorded a number of times (Reach Inv. and Sidestep). The reason for the Reach Inv. is that, in some cases, the actor didn't clearly move the hand back, closer to his/her body, and therefore the algorithm received data with values lower than the thresholds for recognising it. The Sidestep was not recorded 6 times, due to the noise in the data; this can be avoided, by using more than two Kinects. The noise was caused due to the fact that in some cases the actors moved between both Kinects and the stools, which confused the motion capturing system.

Beyond the actual recognition of the motions, the difference between the observed and recorded frames was compared and the results for each actor can be seen in the figures below:

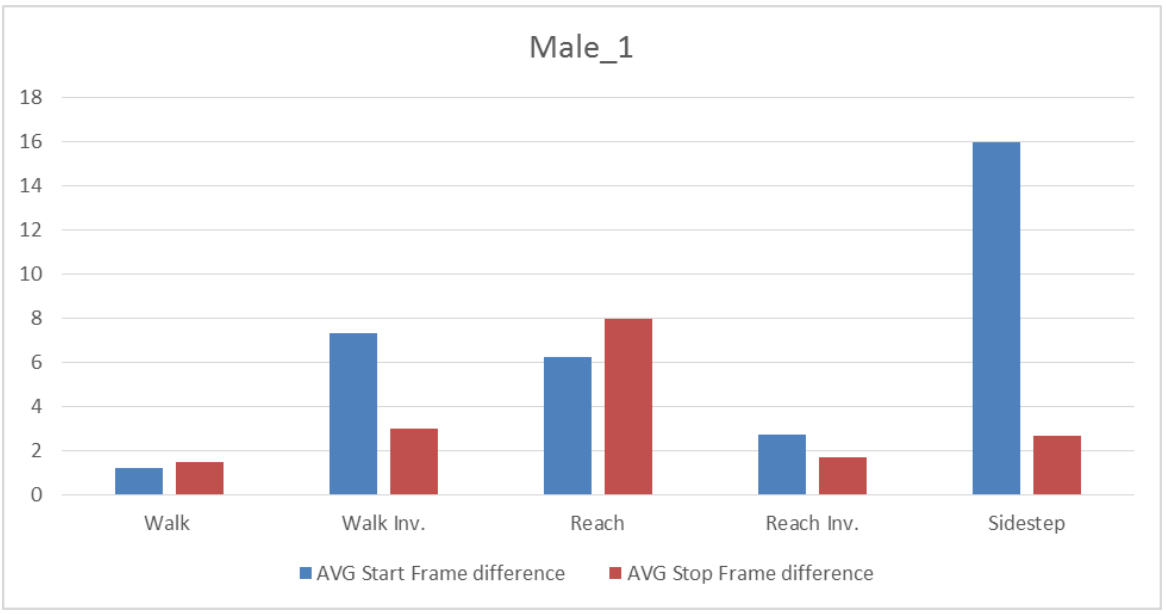

Figure 5: Difference between observed and recorded Start and Stop frames for Male_1.

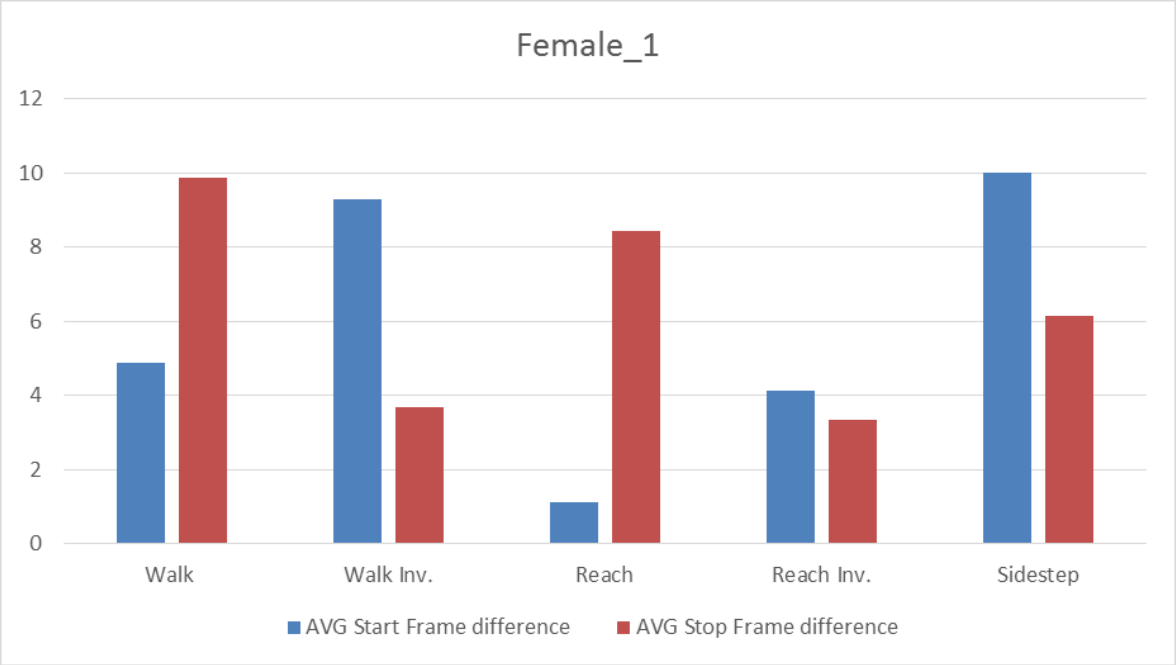

Figure 6: Difference between observed and recorded Start and Stop frames for Female_1.

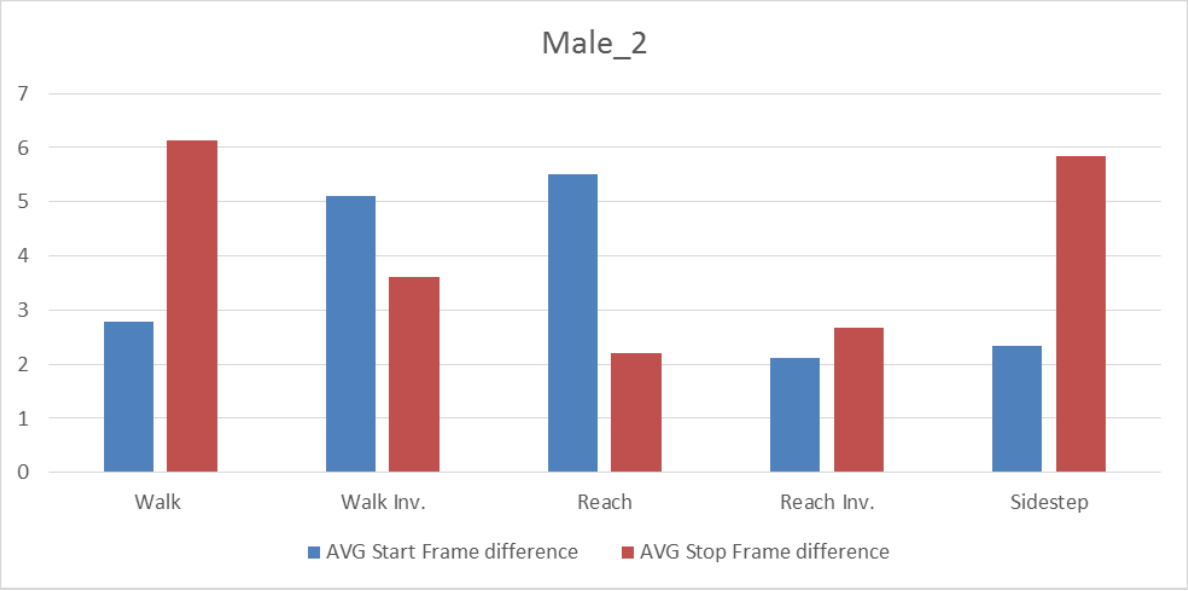

Figure 7: Difference between observed and recorded Start and Stop frames for Male_2.

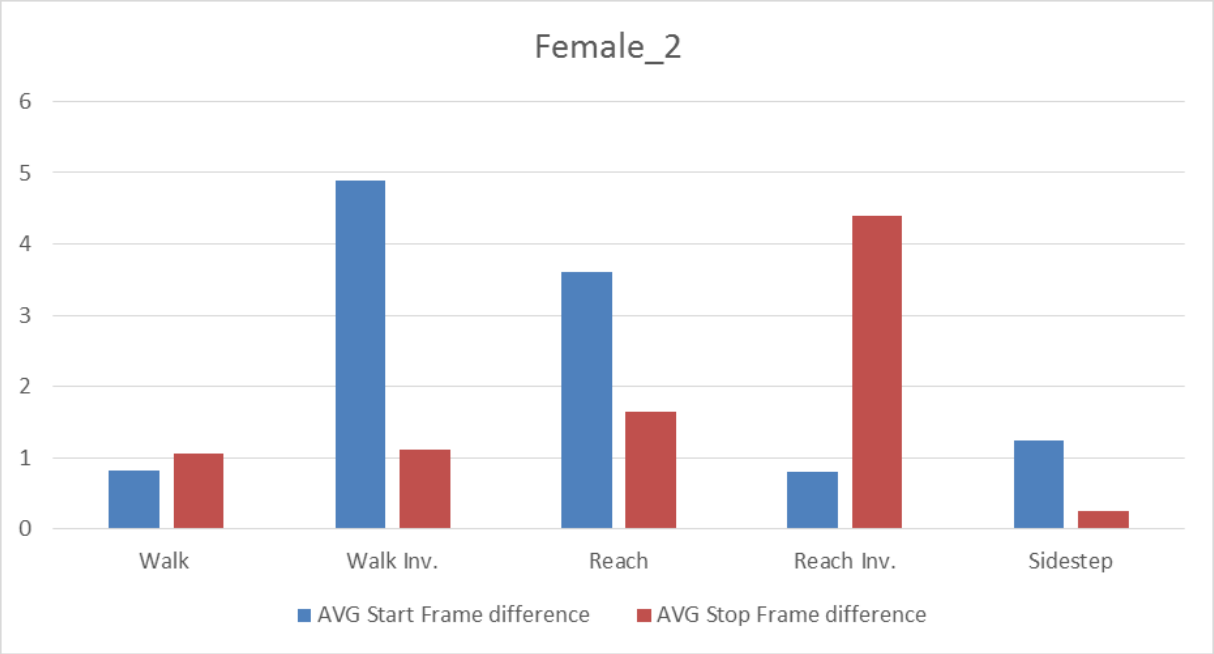

Figure 8: Difference between observed and recorded Start and Stop frames for Female_2.

It can be seen that for the Male_1 and Female_1 actors, which had lower heights, the frame differences were in some cases (e.g. Sidestep) higher than the rest. As explained earlier, it is expected that the performance regarding this motion will be higher when more Kinects will be used in one scene. The average difference for all actors is 4.22 frames, which at 30fps are approximately 140 milliseconds.

4. CONCLUSIONS AND DISCUSSION

Within this report, the preliminary evaluation results were provided for the Motion Recognition Algorithm, which were conducted in M18 of the project. Although some divergence was observed in the recognition of certain motions, the overall effectiveness of the methods used was verified (95%). It is expected that the effectiveness will rise with the use of more sensors (optical). Regarding the deviations between observed and recognised start and stop frames, it is expected that with additional rules and the documentation of more regular nonconformities, the average difference will be dropped even more. The deviations are cause mainly by the definition of the rules for the identification of when a motion starts and stops. The rules will be further elaborated in order to identify standard differences (constant variances) and develop compensating functions in the algorithm.

The next steps regarding the algorithm will be the finalisation of the methods for recognising all motions, which are expected to be completed by M24. In parallel, the integration of the algorithm with the rest of the platform will be completed. The integration includes, the deployment of the algorithm as a web-service and its control from the Enterprise Application Platform (EAP) as well as the Constraints Manager. This will allow, among other things the automatic storage and processing of motions in the Motion Recognition Semantic Repository (MRSR).

ABBREVIATIONS

EAP	Enterprise Application Platform
ME	Motion Element
MoCap	Motion Capture
MRA	Motion Recognition Algorithm
MRSR	Motions Recognition Semantic Repository