Robust and Reliable Gait Recognition in Neurological Clinical Practice

Heinz-Josef Eikerling[1], Michael Uelschen[1], Erik Prinsen[2], Leendert Schaake[2], and Jaap Buurke[2]
[1]University of Applied Sciences Osnabrueck, Faculty for Engineering and Computer Science, D-49076 Osnabrück, Germany
{h.eikerling, m.uelschen}@hs-osnabrueck.de
[2]Roessingh Research and Development, Roessinghsbleekweg 33 B, 7522AH Enschede, The Netherlands
{e.prinsen, l.schaake, j.buurke}@rrd.nl

Background

We describe an automated approach to easily track patients regaining their walking ability while recovering from *neurological diseases* (e.g. stroke). Based on captured gait data and objective measures derived out of it, the *rehabilitation* process can be *optimized* and thus steered. In order to apply such system in clinical practice two key requirements have to be fulfilled:

- the system needs to be applicable in terms of *ease of use* and performance;
- the derived measures need to be *accurate*.

Solution Approach

Up to day, marker-based tracking systems (e.g., Vicon) constitute the gold standard in terms of precision. Deviations of tracked and real marker positions are reported to be below 1 mm. However, this precision comes with a penalty regarding the time needed to accomplish measurements, since patients have to be prepared and the tracked data frequently has to be manually post-processed. Instead we propose a *marker-less tracking system* referred to as *DynMetrics* which permits to perform recordings in a far shorter time interval at the cost of *reduced accuracy*. The reduction seems to be acceptable for the purpose.

Evaluation

Usability

For evaluating the (i) usability of the DynMetrics, 5 physiotherapists were asked to repeatedly (4 times) use the system on patients. Usability was scored using the System Usability Scale (USC) and semi-structured interviews. The USC scores were converted to a value ranging between 0 and 100 (higher score indicates better usability). The physiotherapists rated DynMetrics with an acceptable usability after the fourth use, whereas the usability of the DynMetrics system at first sight is insufficient for two out of the five physiotherapists.

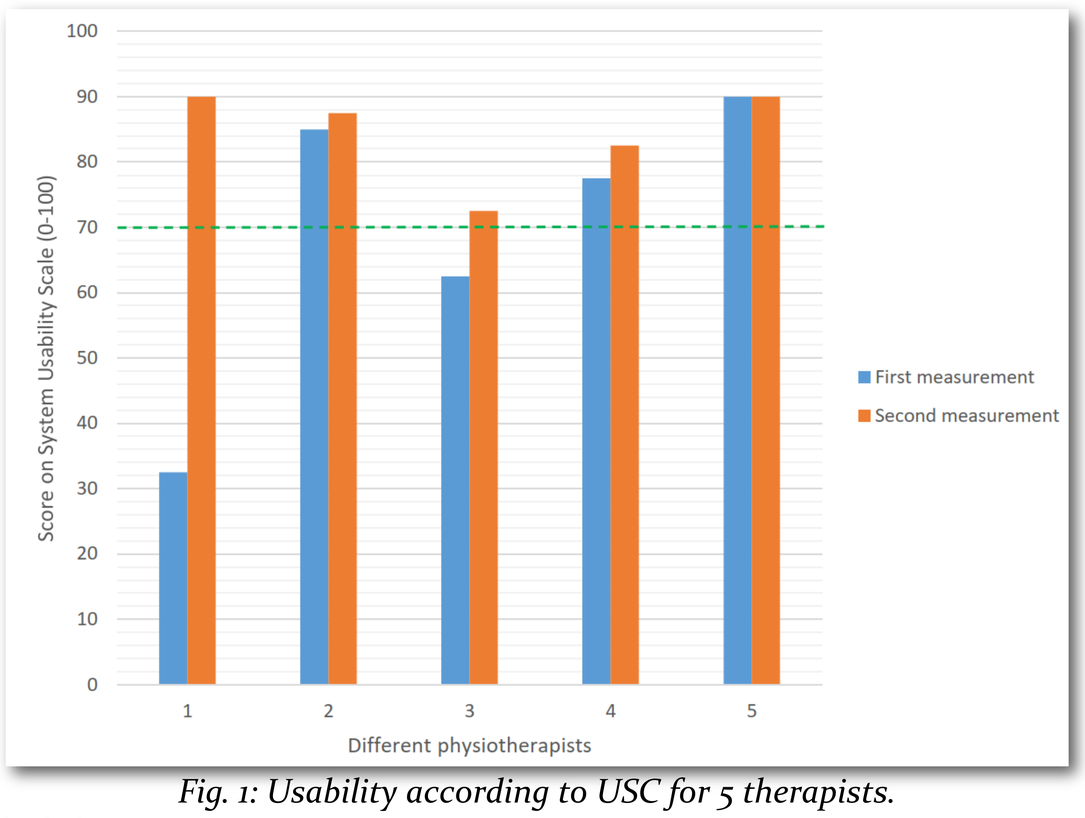

Fig. 1: Usability according to USC for 5 therapists.

Reliability

In order to judge the reliability of the system a comparison of *DynMetrics with Vicon* was conducted. Vicon was taken as the gold standard reference system. First of all, we calculated the tracked positions of the test subjects' joints by DynMetrics and those returned from Vicon. The positioning data and the derived gait parameters (e.g., COM) returned by DynMetrics were found to be good accordance with the reference system.

For matching the gait data **M** (model) and **S** (scene) collected by both tracking systems (Vicon, DynMetrics), an iterative approach was developed. Since the resolutions vary, data set **M** is first scaled with respect to **S**. Subsequently the barycenters of both point clouds are computed and matched. Within the iterations tentative translations using *Umeyama's* algorithm are determined minimizing the error between corresponding points in **M** and **S**.

The loop stops if the error falls below a pre-defined threshold:

```
algorithm IterativeClosestPoint (M, S) {
  /* 2 points sets: model, scene. */
  scale M, S to [0..1] x [0..1]
  centroid M, S
  error ← ∞
  while (error > threshold) {
    find closest neighbour
    T ← transformation() /* Using Umeyama's algorithm. */
    S ← T*S
    error ← distance(M, S)
  }
}
```

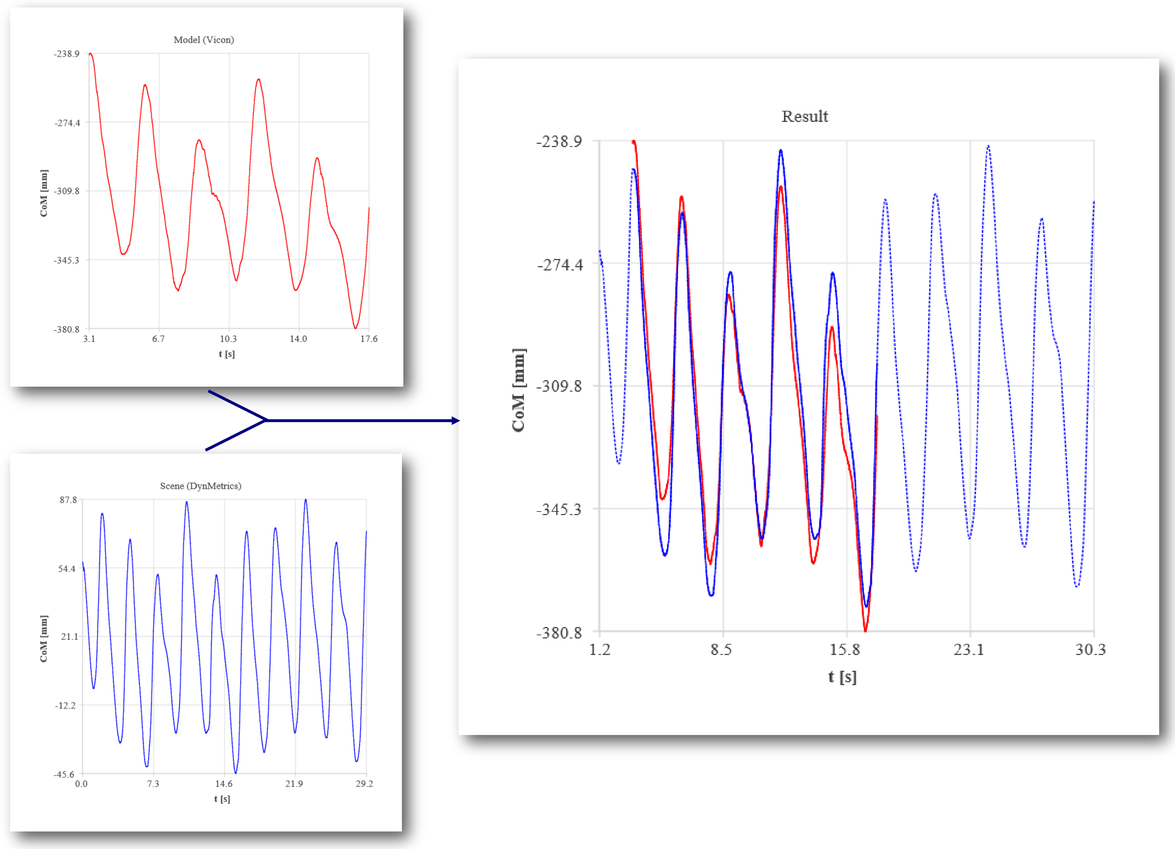

Fig. 2: Comparison of Vicon and DynMetrics for COM.

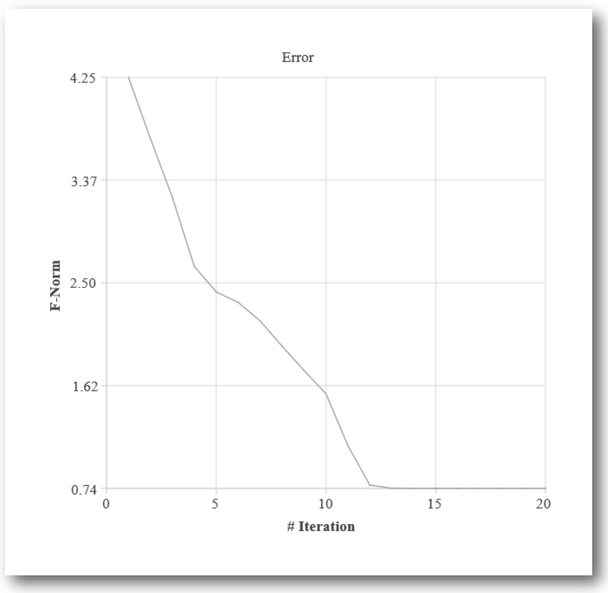

Fig. 3: Setup for measuring reliability and iterative approach for matching.

Conclusions

The reliability and usability study both returned encouraging results. With respect to reliability it could be shown that the system can deliver gait data with sufficient precision in order to measure the centre of mass (CoM) to the base of support relation. Concerning system usability, the convenient provision of elementary as well as more advanced gait metrics were appreciated by the users. Aside from these results, options for future improvements were identified. For instance, the system should become capable to reliably track patients in need of aids like for instance wheeled walkers.

DynMetrics
solution for gait analysis

http://www.dynmetrics.com