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Implementation of a motor functions assessment system based on the MFM scale

Adriana Gomes Lisboa de Sousa[1], Guillaume Thomann[2]*

[1] Univ. Grenoble Alpes, CNRS, Grenoble INP, G-SCOP, 38000 Grenoble, France

* Corresponding author. E-mail address: guillaume.thomann@grenoble-inp.fr

Abstract - An accessible and reliable motor function assessment tool can be achieved by joining clinical scales and motion tracking devices. The Motor Function Measure (MFM) scale is composed of 32 items and validated for patients aged from 6 to 60 years with neuromuscular diseases. Its application is unquestionable for clinical monitoring of patients. In order to reduce scoring variability in the evaluation process and increase patient involvement during MFM application, this work proposes a system prototype capable of capturing, recording and evaluating patient movements based on Kinect and Tablet technologies. An animation system based on a progressive narrative adapted to the MFM scale was also implemented.

Keywords: Clinical Evaluations, MFM Scale, Microsoft Kinect Sensor, Tablet, Animation

1 Introduction

Neuromuscular diseases (NMD) group more than 200 disorders involving injury or dysfunction of the nerves or peripheral muscles. They present as a symptom progressive muscle weakness, very often resulting in loss of autonomy and need for medical care [1]. Epidemiological data show 25,392 people with MND registered in the Netherlands between 2004 and 2016 [2]. In France, an estimation of 13,000 people have been affected with Steiner's dystrophy diseases alone, Myasthenia, facioscapulohumeral muscular dystrophy, and inflammatory myopathy [3]. The estimated cost of medical appointments, medications, direct and indirect care, and early retirement in the US, calculated for the three most common diseases (Amyotrophic lateral sclerosis, Duchenne muscular dystrophy, and myotonic dystrophy) are between $ 1.07 and 2.26 billion per year [4]. These results stimulate investment and research initiatives in treatment and care.

The procedure after a diagnosis of an NMD is a specialized and multidisciplinary follow-up of the patients. For this, a full day, 1-2 times a year, is foreseen for consultations with different specialists, complementary exams, assessments, help with social and school integration, as well as guidelines [5]. Regarding evalua-

tions, the focus is on the musculoskeletal system and functional impairment. The investigation of muscle performance is performed by physiotherapists, usually using motor function assessment scales [6].

The Motor Function Measurement (MFM) scale is a 32-items motor function scale validated for patients aged from 6 to 60 years with NMD [7]. It is a rigorous evaluation protocol with precise instructions on how the proposed movement should be performed. It allows clinical follow-up of the disease, anticipates patient adaptive needs and assesses the impact of therapies or interventions.

The issue around the use of MFM is the same with any other scale: the variability of results, which are dependent on the subjectivity of the evaluator [8,9]. In addition, and still within the context of NMD, there is sometimes a lack of cooperation from younger patients during motor assessments, associated with tiredness due to the many tasks performed during the evaluation day. In this paper, authors propose the creation of an integrated system to improve reproducibility of evaluations and patient engagement during MFM evaluations. The system makes use of low cost technology (motion sensor and digital tablet) and software designed for motion capture and analysis, animations and feedback, always respecting the MFM paradigms regarding the main users: physiotherapist and young patients.

2 Review

The ability to analyze movements is an essential prerequisite for motor function assessment. However, qualitative analysis, commonly used for motor scales are dependent on the observer's ability and don't allow the registration of quantitative variables [10]. The three-dimensional study of human movements offers the possibility of quantitative measurements, requiring appropriate methods and equipment [11]. The democratization of technologies such as motion sensors and tablets has enabled new approaches to human motion analysis research. The sensors based on the Time-of-Flight principle (ToF) (Kinect V2 sensor for instance) using silhouette recognition techniques and calculation of a 3D numerical skeleton have shown great potential for applications in motor rehabilitation of balance disorders and postural control, except of upper limbs and neurological disorders [12, 13, 14]. It also has good results for gait analysis [15,16], sign language analysis [17], sports training [18] and ergonomics [19].

In the case of Tablet, some studies have shown that technology has a great potential for health applications. Easy portable and with robust media, the manipulation of an interactive interface allows motor therapies for stroke patients [20,21] and fine hand and finger movement assessments [22, 23,24].

Another advantage of using these technologies, besides the low cost, is the use of open platforms, which enables the development of specific applications, such as games and animations for the purpose of assessment and motor rehabilitation. The use of serious games/animations has the advantage of creating a playful and inter-

active environment, adaptable to the needs and interests of the user, being a motivational and complementary tool for rehabilitation, evaluation and motor training [25, 26]. Within the design of serious games, it is essential to provide functionality for patients and therapists: adequacy to patients' skills and needs, relevant tasks, feedback system, and facilities to guide the therapist all along the patient progress [27].

Technology-assisted rehabilitation and evaluation enables the creation of solutions able to contribute to the improvement of the process and clinical treatment adopted. Within the working context described, assessment of NMD patients, an evaluation automation system aims to make patient, therapist and machine interaction simple and more motivating.

3 Method

This work was developed within 4 axis: (1) Technologies to be used, (2) Recognition of activities and automatic motor functions assessment, (3) Implementation of animations and (4) Development of management interface. Each axis was developed in partnership with therapists. We considered the potentialities of the available technologies, reliability of measurements, integration with clinical practices and theoretical framework.

4 Results

4.1 Motor function assessment by Kinect sensor

To perform full body evaluation, the KiMe2 software was implemented, able to measure motor skills, analyze and communicate the results of 14 of the 32 MFM items. Upon detection of the numerical skeleton by the Kinect, KiMe2 converts raw data into kinematic data established by therapists and MFM standards: starting position, posture, joint angles, time to perform the task, etc. From the data recorded, an automatic analysis is performed providing different levels of information about the movements executed: automatic score, justification of the score, calculations and graphs regarding position and joint angle. KiMe2 offers the possibility of movement reconstruction of the registered skeleton. Figure 1 illustrates the proposed architecture.

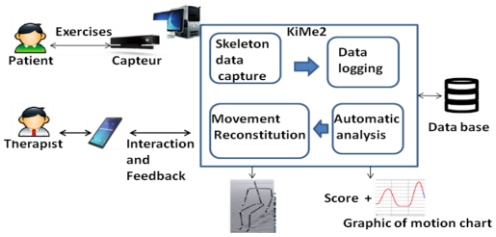

Fig.1. KiMe2 Usage Architecture

4.2 Motor function assessment by Tablet

For the evaluation of the distal motor skills of the upper limbs, 3 items (18, 19 and 22) of the MFM were implemented on a Tablet for automatic evaluation. TabMe2 software is able to identify finger/pen touch and compute position, time and speed parameters for the calculation of score. The feedback of the evaluations is given in the form of a score, justification of the score and reconstitution of the traces in the form of an animation. The raw data and the drawings of the evaluations are registered in a pdf file. Figure 2 illustrates the proposed architecture for the TabMe2 software.

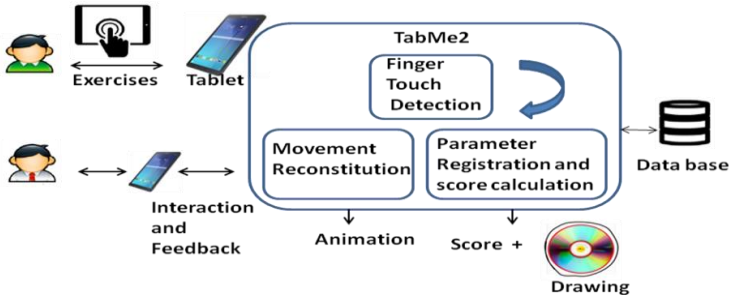

Fig. 2. TabMe2 Usage Architecture

4.3 Animation design

Within the scope of making MFM assessments more playful, animations have been developed based on a game scenario that considers all MFM protocol constraints, the clinical context of NMD, the patient, and the technologies used. The animations unfold within a progressive narrative, which gives initial instruction on how each item should be performed. Feedback to the patient is based on the final score, always with a motivating message. The animations were developed with

open source programs Blender and Animaker. Fig 3 shows some of the screens which are part of the animations.

Fig. 3. Animations Proposed

4.4 Hardware and Software Integration

The integration between hardware (tablet and motion sensor), KiMe2 software (Microsoft studio) and TabMe2 software (Android Studio) have been optimized for use within clinical practice. A digitization of the evaluation sheet (tool commonly used in MFM practice) was integrated to the Tablet interface. From the evaluation sheet, the therapist may control KiMe2 remotely (WiFi), perform hand evaluations (TabMe2), consult the MFM driving manual, present the patient's animations and formalize their scores and comments. The fundamental principle of the system is to let therapist deciding or not to take into account automatic score, justification of the score, calculations and graphs. Control of the system via Tablet still has the advantage of allowing the therapist to remain always beside the patient.

5 Conclusion and perspective

This paper proposes a new approach to evaluate the motor functions of young patients suffering from neuromuscular diseases, based on MFM scale. The prototype makes use of motions sensor and tablet technologies and therefore offers more quantitative capabilities for motion analysis. KiMe2 and TabMe2 are two software developed for automated analysis that can help reproducibility of evaluations. The complete system is being tested, and patient measurements are being collected. The introduction of animations in the protocol has the ambition to transform the perception of the patients' motor functions assessment phase. The proposed system is more attractive for children to perform the movements, indeed as low motivation and lack of engagement are important barriers to performing the exercises.

References

1. Urtizberea, J.-A.; Boucharef, W.; Frischmann, M. Maladies neuromusculaires: évolution des concepts médicos cientifiques et des pratiques de soins. Neuropsychiatrie de l'enfance et de l'adolescence, v. 56, n. 2, p. 51-57, (2008).
2. Deenen, Johanna CW et al. The epidemiology of neuromuscular disorders: Age at onset and gender in the Netherlands. Neuromuscular Disorders, v. 26, n. 7, p. 447-452, 2016.
3. Institut des Neurosciences Cliniques de Rennes: INCR< https://www.incr.fr/>.
4. Larkindale, Jane et al. Cost of illness for neuromuscular diseases in the United States. Muscle & nerve, v. 49, n. 3, p. 431-438, 2014.
5. Chabrol, B.; Mayer, M. Principes de prise en charge multidisciplinaire des dystrophies musculaires de Duchenne. Archives de pédiatrie, v. 22, n. 12, p. 12S69-12S72, 2015.
6. Eppinger S.D. and Salminen V.K. Patterns of product development interactions. In International Conference on Engineering Design, ICED'01, Vol. 1, Glasgow, August 2001, pp.283-290 (Professional Engineering Publishing, Bury St Edmunds).
7. Jensen, Mark P.; ABRESCH, Richard T.; CARTER, Gregory T. The reliability and validity of a self-report version of the FIM instrument in persons with neuromuscular disease and chronic pain. Archives of physical medicine and rehabilitation, v. 86, n. 1, p. 116-122, 2005
8. Bérard, C. et al. La mesure de fonction motrice, outil d'évaluation clinique des maladies neuromusculaires. Étude de validation. Revue Neurologique, v. 162, n. 4, p. 485-493, 2006.
9. Hobart, Jeremy; CANO, Stefan. Rating scales for clinical studies in neurology—challenges and opportunities. US Neurol, v. 4, n. 1, p. 12-18, 2008.
10. Cook, Gray et al. Functional movement screening: the use of fundamental movements as an assessment of function-part 1. International journal of sports physical therapy, v. 9, n. 3, p. 396-409, 2014.
11. Van Hartingsveldt, Margo J.; CUP, Edith HC; OOSTENDORP, Rob AB. Reliability and validity of the fine motor scale of the Peabody Developmental Motor Scales–2. Occupational therapy international, v. 12, n. 1, p. 1-13, 2005.
12. Cuesta-Vargas, Antonio I.; GALÁN-MERCANT, Alejandro; WILLIAMS, Jonathan M. The use of inertial sensors system for human motion analysis. Physical Therapy Reviews, v. 15, n. 6, p. 462-473, 2010.
13. Wasenmüller, Oliver; Stricker, Didier. Comparison of kinect v1 and v2 depth images in terms of accuracy and precision. In: Asian Conference on Computer Vision. Springer, Cham, 2016. p. 34-45.
14. Lee, Seung Hak et al. Measurement of shoulder range of motion in patients with adhesive capsulitis using a kinect. PloS one, v. 10, n. 6, p. e0129398, 2015.
15. Yeung, L. F. et al. Evaluation of the Microsoft Kinect as a clinical assessment tool of body sway. Gait & posture, v. 40, n. 4, p. 532-538, 2014.
16. Auvinet, Edouard et al. Detection of gait cycles in treadmill walking using a Kinect. Gait & posture, v. 41, n. 2, p. 722-725, 2015.
17. Galna, Brook et al. Precisão do sensor Microsoft Kinect para medir o movimento em pessoas com doença de Parkinson. Marcha e postura , v. 39, n. 4, p. 1062-1068, 2014.
18. Gameiro, João; Cardoso, Tiago; Rybarczyk, Yves. Kinect-sign: teaching sign language to "listeners" through a game. In: International Summer Workshop on Multimodal Interfaces. Springer, Berlin, Heidelberg, 2013. p. 141-159.
19. Cassola, Fernando et al. Online-Gym: a 3D virtual gymnasium using Kinect interaction. Procedia Technology, v. 13, p. 130-138, 2014.
20. Plantard, Pierre et al. Validation of an ergonomic assessment method using Kinect data in real workplace conditions. Applied ergonomics, v. 65, p. 562-569, 2017
21. Carabeo, Christle Grace G. et al. Stroke patient rehabilitation: A pilot study of an android-based game. Simulation & Gaming, v. 45, n. 2, p. 151-166, 2014.

22. Rand, D. et al. The use of the iPad for poststroke hand rehabilitation; a pilot study. In: 2013 International Conference on Virtual Rehabilitation (ICVR). IEEE, 2013. p. 109-113.
23. Lin, Po-Chieh et al. A digital assessment system for evaluating kinetic tremor in essential tremor and Parkinson's disease. BMC neurology, v. 18, n. 1, p. 25, 2018.
24. Larsen, Lisbeth H. et al. Changes in corticospinal drive to spinal motoneurones following tablet-based practice of manual dexterity. Physiological reports, v. 4, n. 2, 2016.
25. Kizony, Rachel, et al. Tablet apps and dexterity: Comparison between 3 age groups and proof of concept for stroke rehabilitation. Journal of Neurologic Physical Therapy, 2016, 40.1: 31-39.
26. Valladares-Rodríguez, Sonia, et al. Trends on the application of serious games to neuropsychological evaluation: a scoping review. Journal of biomedical informatics, 2016, 64: 296-319.
27. Hocine, Nadia, et al. Adaptation in serious games for upper-limb rehabilitation: an approach to improve training outcomes. User Modeling and User-Adapted Interaction, 2015, 25.1: 65-98.
28. Paraskevopoulos, I. T, et al. (2014). Design guidelines for developing customised serious games for Parkinson's Disease rehabilitation using bespoke game sensors. *Entertainment Computing*, *5*(4), 413-424.