TITLE PAPER

**ABSTRACT**

**CCS Concepts**

**• Information systems~Multimedia information systems   • Computing methodologies~Virtual reality • Information systems~Multimedia information systems   • Human-centered computing~Graphical user interfaces • Applied computing~Life and medical sciences.**

**General Terms**

Design, Experimentation, Performance.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [Permissions@acm.org](mailto:Permissions@acm.org).  
REHAB 2016, October 13-14, 2016, Lisbon, Saudi Arabia   
© 2016 ACM. ISBN 978-1-4503-4765-5/16/10…$15.00   
DOI: <http://dx.doi.org/10.1145/3051488.3051517>

**Keywords**

Virtual Rehabilitation; Rare Diseases; Physical Therapy; Numbness; Tingling; Range-of-motion; Grip strength.

# INTRODUCTION

Rare Diseases (RD), or "orphan diseases", are often serious, chronic and progressive diseases, they are named depending on the prevalence of the disease in each country.

Public and private health institutions have expressed the main objective "ensuring conditions in which people can be healthy," generating solutions if unexpected or persistent health problems or environmental factors appear that put large populations at risk.

Health institutions work with professionals from different areas to ~~investigate the causes~~ research the reasons that put the lives and health of the populations at risk in order to prevent, ~~mitigate~~ alleviate or suppress the ~~inconveniences generated~~ disorders produced. However, this action does not happen with the diseases known as rare, which affect few subjects and are dispersed in the world with a variety of disorders and symptoms due to genetic variations or to the stage of appearance in the subject.

The European Union considers a rare disease if 1:2,000 subjects ~~has~~ have a RD ~~that disease~~ (Eurordis, 2014). In Norway 1:10,000 subjects have a RD (Helsenorge, 2016). In Taiwan 1:10,0000 subjects have been diagnosed with a RD (mediographic, 2015). In Italy 1:20,000 subjects suffered a RD (mediographic, 2015). In the United States 1:5.000 subjects present symptoms related to a RD (Cortés, 2015; Genetic and Rare Diseases Information Center, 2017a). In Japan 1:2,500 subjects have a RD (Cortés, 2015).

There are about 5.000 to 8.000 RD, 80% are of genetic origin and the difference is due to bacterial or viral infections, environmental factors or allergies ([Alonso, Hawrylak, & Gómez, 2010](#_ENREF_4); [Boycott et al., 2013](#_ENREF_26); [Institute of Medicine National Academies of Sciences, 2010](#_ENREF_108)). Those generate alterations in the performance of activities of daily living (ADLs). Despite their severity, some ~~rare diseases~~ RD are compatible with a good quality of life if diagnosed early and treated optimally [1].

Patients with RD ~~rare diseases~~, in addition to facing the symptoms of their pathology, must experience the lack of knowledge and experience of clinical experts, adding the limitations of access to health systems and low availability of drugs ([Antiñolo & Lozano, 2010](#_ENREF_7))~~; . T~~his causes delays in diagnosis, inadequate treatment and even harmful treatment which could affect the subjects in their mental, behavioral and sensory abilities ([Budych, Helms, & Schultz, 2012](#_ENREF_29)).

Information on diagnostics, therapies, treatments and research on RD is often scarce or difficult for health professionals, patients and researchers to access[2]. RDs remain hidden due to inadequate recording of data in isolated, independent information systems. The Health System needs to generate a strategy for the National and Global Registry of RD [3].

The most common RDs are: Huntington's Disease, Spina Bifida, Fragile X Syndrome, Guillain-Barré Syndrome, Crohn's Disease, Cystic Fibrosis, Duchenne Muscular Dystrophy and Amyotrophic Lateral Sclerosis[4] (2017).

The most frequent RD in infants are Osteogenesis or Imperfect Osteogenesis, Phenylketonuria, Oculocutaneous Albinism, Acondroplasia and the least frequent is Encephalopathy [5].

Encephalopathy is a disease of the brain, which affects it structurally and functionally, including many age-related syndromes, with specific types of seizures and neurological characteristics. A subject with encephalopathy generally has 1) altered mental status; 2) decreased cognitive and intellectual ability; 3) lack of concentration; 4) involuntary muscle spasm; 5) rapid and involuntary eye movement; 6) tremors; 7) atrophy and/or muscle weakness; 8) dementia; 9) convulsions; and 10) loss of speech ability (Standen et al., 2015)

A particular type of encephalopathy is Epileptic Encephalopathy (EE) which has a panorama of genetic mutations (e.g., KCNQ2, SCN1A, SCN2A) associated with neurological disorders and epilepsies, which proliferate new types of rare diseases.

Subjects with EE have very frequent and severe seizures (Dulac, 2001; Nickels & Wirrell, 2017), which causes progressive brain dysfunction (Khan & Al Baradie, 2012), periods of regression in cognitive development (Berg 2010), mental and neurological deterioration at cognitive, sensory and/or motor level (Capovilla, Wolf, Beccaria, & Avanzini, 2013).

Brain dysfunction is a less serious disorder that causes learning issues in the children (dyslexia, dyscalculia, dysortography and dysgraphia), psychomotor disorders, disorders in cognitive processes (memory, reasoning and executive functions of location) and disorders of oral language [6].

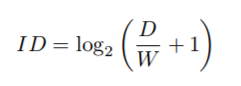
Memory loss causes Developmental Coordination Disorder (DCD). A subject with DCD experiences difficulties in the development of motor skills and deficits in spatial skills [7]

We are concerned about the effects of rare diseases, therefore, we developed an application (RARESPATIAL) in Unity with a low cost optical tracking device named Leap Motion that supports the recovery of spatial skills (location and positioning) with order, constancy and fun. For application development we focus on the principles of Perfetti and Fitts Law.

Perfetti, also called Cognitive Therapeutic Exercise, is a rehabilitative method, which aims to activate cognitive processes in motor recovery, performing exercises with open eyes and closed eyes. This allows the recovery of perception, memory, language, etc., allowing the subject to relate to the outside world. This respects the progression of learning; therefore, its application has different levels of difficulty.

So, matching the movement limits and capabilities of humans with interaction techniques on computing systems is an important area of research in human‐computer interaction

The Fitts Law controls the limits of movement and human-computer interaction (HCI). It also states that ~~the~~ time period required moving, acquiring or selecting a target with a pointer (e.g. mouse cursor, Leap Motion hand) is a function of the distance to the target (D) divided by the size of the target (W). These two geometric parameters are combined in the Difficulty Index (ID) [8], [9]

 (1)

The difficulty index is linearly proportional to the movement time (MT), the greater the distance and the smaller the size of the target, the more time it will take. According to its law, fast movements and small targets result in higher error rates, due to speed-precision compensation.[8]

 (2)

When comparing experimental conditions, measuring the human performance (TP) is recommended. This provides a single measure, the combination of speed and precision in reaching a target, averaging over the range of difficulty index ~~indices~~. The performance has the units of bits per second, analogous to the amount of information, and it is defined as the rate of difficulty over the movement time [8]

 (3)

The software strengthens the cognitive perception, accelerates the reaction of the knowledge of the spatial location, with levels of teaching-learning and validation or playability. The basic level with 2 panels (top-down or left-right), intermediate level with four panels (left-up, left-down, right-up, right-down) and the advanced level with 9 panels (left-up, left-down, right-up, right-down, left-center, right-center, up-center, lower-center and middle-center).

The application provides a teaching process, then a learning process and finally a process of verification of the learning level by interacting with the application through Leap Motion.

The software to interact in the teaching-learning p harmful rocess uses visual and/or auditory feedback and for the validation process uses auditory and tactile feedback in virtual environments.

In this paper, we present outcomes ~~the results~~ of experimenting with learning spatial skills with healthy children ages 5 to 10 without nay motor and cognitive disorder. We pretend to test ~~intend to evaluate~~ the effectiveness of the Fitts Law, Perfetti method and ~~the~~ movement performance in VR.

# RELATED WORK

Examples of Virtual Rehabilitation in patients with neurological disorders.

Examples of Virtual Rehabilitation in childhood with disorders (children with Cerebral Palsy, children with Autistic spectrum disorders, etc)

Técnica de perffeti con las 2 etapas que tiene, describiendo las 2 etapas, pasado en el correo de Sergio.

Rehabilitacion virtual donde se ha aplicado la técnica perfetti, pasados en el correo.

There are no studies of technological systems based on virtual Rehabilitation for children with epileptic encephalopathy by using the perfetti method.

Fitts law applies in various 1D, 2D and 3D environments.The Fitts law in one-dimensional environments allows you to perform a practical activity by evaluating human performance through a video. The task is, gunshot competition seeking to maximize the score, which requires an explicit cognitive strategy and biomechanical coordination of the whole body[10]. The Fitts law was applied in three dimensions to examine the interaction based on gestures, including three input devices (mouse, touch screen and leap motion with cameras of different range), time control was done manually with a stopwatch. Motion time, error rate and performance were calculated for each input technology [11].

The results showed that the average movement time was highly correlated with the difficulty rate of the target for all devices, demonstrating that Fitts law can be extended and applied, therefore, it is intended to check the Fitts law evaluated the execution of tasks with the left and right hand, as well as applying perfetti principles with open and closed eyes.

# METHODS

## The Participants

1. Grupo de control de niños de 5 años. Grupo experimental de niños de 9 y 10 años (10 niños) Muestras independientes por tener edades diferentes. Niños sin ningún tipo de lession sin desordenes.
2. Analizar de la varianza ttest SPSS o R. Graficas de Barras percentiles
3. Reacción a nivel kinematico Tiempos de reacción, Tiempo para completar la tarea.
4. Memoria espacial a corto plazo.
5. Validar en base a la ley de Fitts. En función del grado de complejidad que quieres alcanzar un obejtivo, te custa mas ti
6. Los tiempos para completar una tarea son mayores en función dela edad de un niño.
7. seran

## The System

Our technological system is comprised of

## VR exercises

# PROCEDURE

Before the first session, the therapist tested all the participants

Figure 2. Participant using the system.

.

# RESULTS

# DISCUSSION AND CONCLUSIONS

# ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of Universidad de las Fuerzas Armadas-ESPE in Ecuador. This project was funded by the Gobierno de Aragón, Departamento de Industria e Innovación, y Fondo Social Europeo "Construyendo Europa desde Aragón".

# REFERENCES

1. Kostopoulos D. Treatment of carpal tunnel syndrome: a review of the non-surgical approaches with emphasis in neural mobilization. J Bodyw Mov Ther 2004; 8:2–8.
2. Heuser A, Kourtev H, Winter S, Fensterheim D, Burdea G, Hentz V, Forducey P. Telerehabilitation using the Rutgers Master II glove following carpal tunnel release surgery: proof-of-concept. IEEE Trans Neural Syst Rehabil Eng. 2007Mar;15(1):43-9.
3. Thiese MS, Gerr F, Hegmann KT, Harris-Adamson C, Dale AM, Evanoff B, Eisen EA, Kapellusch J, Garg A, Burt S, Bao S, Silverstein B, Merlino L, Rempel D. Effects of varying case definition on carpal tunnel syndrome prevalence estimates in a pooled cohort. Arch Phys Med Rehabil. 2014 Dec;95(12):2320-6.
4. Castro, A. do A. e, Skare, TL, Nassif PAN, Sakuma AK, Barros WH Sonographic diagnosis of carpal tunnel syndrome: a study in 200 hospital workers. Radiologia Brasileira. 2015;48(5), 287–291.
5. Alfonso C, Jann S, Massa R, Torreggiani A. Diagnosis, treatment and follow-up of the carpal tunnel syndrome: a review. Neurol Sci. 2010 Jun;31(3):243-52.
6. Newington L, Harris EC,Walker-Bone K. Carpal tunnel syndrome and work. Best Practice & Research. Clinical Rheumatology. 2015; 29(3), 440–453.
7. Fu T, Cao M, Liu F, Zhu J, Ye D, Feng X, Xu Y, Wang G, Bai Y. Carpal tunnel syndrome assessment with ultrasonography: value of inlet-to-outlet median nerve area ratio in patients versus healthy volunteers. PLoS One. 2015 Jan 24;10(1):e0116777.
8. Phalen GS.The carpal-tunnel syndrome. Seventeen years’ experience in diagnosis and treatment of six hundred fifty-four hands. J Bone Joint Surg Am 1966; 48: 2112228.
9. Madenci E, Altindag O, Koca I, Yilmaz M, Gur A. Reliability and efficacy of the new massage technique on the treatment in the patients with carpal tunnel syndrome. Rheumatol Int. 2012 Oct;32(10):3171-9.
10. Fernández-de-Las Peñas C, Ortega-Santiago R, de la Llave-Rincón AI, Martínez-Perez A, Fahandezh-Saddi Díaz H, Martínez-Martín J, Pareja JA, Cuadrado-Pérez ML. Manual Physical Therapy Versus Surgery for Carpal Tunnel Syndrome: A Randomized Parallel-Group Trial. J Pain. 2015 Nov;16(11):1087-94.
11. Johansson BB. Multisensory stimulation in stroke rehabilitation. Front Hum Neurosci. 2012 Apr 9;6:60.
12. Brunner I, Skouen JS, Hofstad H, Strand LI, Becker F, Sanders AM, Pallesen H, Kristensen T, Michielsen M, Verheyden G. Virtual reality training for upper extremity in subacute stroke (VIRTUES): study protocol for a randomized controlled multicenter trial. BMC Neurol. 2014 Sep 28;14:186.
13. Albiol-Pérez S, Gil-Gómez JA, Llorens R, Alcañiz M, Font CC. The role of virtual motor rehabilitation: a quantitative analysis between acute and chronic patients with acquired brain injury. IEEE J Biomed Health Inform. 2014 Jan;18(1):391-8.
14. Albiol-Pérez S, Forcano-García M, Muñoz-Tomás MT, Manzano-Fernández P, Solsona-Hernández S, Mashat MA, Gil-Gómez JA. A novel virtual motor rehabilitation system for Guillain-Barré syndrome. Two single case studies. Methods Inf Med. 2015;54(2):127-34.
15. Merians AS, Poizner H, Boian R, Burdea G, Adamovich S. Sensorimotor training in a virtual reality environment: does it improve functional recovery poststroke? Neurorehabil Neural Repair 2006; 20:252–267.
16. Tansel H, Sinan K, Doga D, Marc W., Kyle E. MoMiReS: Mobile mixed reality system for physical & occupational therapies for hand and wrist ailments. Innovations in Technology Conference (InnoTek), 2014 IEEE.
17. Gil-Gómez J.-A., Gil-Gómez H., Lozano-Quilis J.-A., Manzano-Hernández P., Albiol-Pérez S., Aula-Valero C.: SEQ: suitability evaluation questionnaire for virtual rehabilitation systems. Application in a virtual rehabilitation system for balance rehabilitation. In Proceedings of the 7th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth '13). 335-338 (2013).