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REHABILITATION GAMES FOR JUVENILE RHEUMATIC DISEASE

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Sommario

La riabilitazione motoria è una terapia molto importante che può migliorare la qualità di vita di persone con funzionalità motorie limitate. Questo tipo di terapia viene svolta facendo eseguire ripetutamente al paziente una serie di semplici esercizi. È proprio questa monotonia una delle cause per cui alcuni pazienti che non sono costantemente sotto la supervisione dei fisioterapisti tendono a non eseguire con continuità gli esercizi o, addirittura, ad abbandonare la terapia. Da qui la necessità di trovare dei metodi alternativi che stimolassero il paziente a eseguire tali esercizi con continuità. È qui che entrano in gioco i *serious games*, i quali sfruttano la caratteristica fondamentale dei videogames, cioè il divertimento, per raggiungere uno scopo più utile, come, nel nostro caso, quello della riabilitazione.

In questa tesi esponiamo il nostro lavoro relativo alla progettazione di una serie di *exergames* (videogiochi che hanno come scopo quello dell'esercizio fisico) per aiutare pazienti affetti da *Artrite Idiopatica Giovanile* nel loro percorso riabilitativo. Ci siamo concentrati, in particolare, sulla riabilitazione dei polsi. Per il design dei nostri giochi abbiamo seguito la metodologia di *iterative design*, che consiste nel testare, analizzare e rifinire ciclicamente il prototipo del proprio progetto al fine di migliorare il prodotto finale. Il nostro obiettivo principale è stato quello di progettare e creare dei giochi che fossero soprattutto divertenti, invogliando così i pazienti a utilizzarli e quindi a eseguire la terapia motoria, ma allo stesso tempo utili ai fisioterapisti per l'analisi delle performance dei pazienti. Per fare ciò, ci siamo basati su un insieme di regole di game design, alcune generiche per la creazione di videogiochi, altre specifiche per i giochi che hanno come scopo la riabilitazione. Abbiamo così progettato quattro videogiochi, ciascuno di un genere diverso dall'altro per cercare di venire incontro ai gusti di un pubblico

il più vasto possibile. Per ciascun gioco abbiamo progettato un gameplay il più intuitivo possibile, in modo da renderlo immediatamente fruibile dal paziente. Abbiamo inserito, inoltre, alcune caratteristiche che aumentassero l'interesse e l'impegno del paziente, come ad esempio il sistema di punteggi o la possibilità di adattare la difficoltà in base al proprio livello di abilità. Infine, abbiamo progettato una serie di caratteristiche che permettessero ai fisioterapisti di avere un feedback sia qualitativo che quantitativo relativamente alle performance dei pazienti. Questi feedback possono essere utili sia per valutare come il paziente svolge i propri esercizi quando è da solo, ad esempio a casa, sia per capire per quali tipologie di movimenti il paziente ha più bisogno di esercitarsi e quindi personalizzare maggiormente la terapia.

Con l'aiuto dei fisioterapisti e dei pazienti della clinica Pediatrica G. e D. de Marchi, abbiamo svolto delle sessioni di test in cui abbiamo raccolto i feedback sia degli uni che degli altri. In particolare le prime due sessioni sono state utili per validare quanto avevamo progettato, mentre nelle successive abbiamo analizzato come i pazienti interagivano con i giochi e come si adattavano ad essi con il susseguirsi delle partite. I feedback da parte sia dei pazienti che dei fisioterapisti sono stati positivi. I primi si sono divertiti testando i giochi e hanno rilasciato commenti positivi a riguardo, i secondi hanno apprezzato sia le funzionalità specifiche per il loro lavoro che avevamo inserito nei giochi, che la reazione dei pazienti ai giochi. In particolare il modo in cui i pazienti hanno svolto facilmente esercizi che durante le sessioni di terapia standard trovavano difficili.

Abstract

One issue of the standard physical therapy used in the rehabilitation process is that patients tend to have problems in performing it regularly, due to the tediousness of repeating simple exercises. Thus it is important to find alternative ways of making physical therapy that would encourage patients to keep exercising. This thesis concerns the development of a set of rehabilitation games for children affected by *Juvenile Idiopathic Arthritis*. Focusing on the wrist rehabilitation we designed a set of four games. We diversified our gaming offer designing different kind of games in order to appeal a wider range of people. For the design of the games we used the iterative design approach, that is a cyclic process of prototyping, testing, analyzing and refining our games. The main goal was to design games that would entertain the patients encouraging them to play and so to perform their exercise, preventing them from quitting the physical therapy. We also designed some features that would help the therapists in analyzing the patients' performances and progress and give some useful information about possible improvements in the therapy. With the help of a team of therapists and patients from Clinica Pediatrica G. e D. De Marchi we performed a set of experimental sessions in order to validate our designs and to analyze how the patients interacted and adapted to the games. Feedbacks were good from both the patients, who enjoyed playing the games, and the therapists, who were satisfied with the features that we designed and with the patients' response to the games.

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Chapter 1

Introduction

In recent years a new kind of videogames, called serious games, has become increasingly relevant. The core idea of serious games is mixing the entertaining factor typical of classic videogames with a useful purpose that helps the players acquiring new abilities or improving those that they already have. Serious games have been developed in several environments, for different purposes: there are educational games for learning purposes, games used for military training, games for healthcare, and much more.

In this work we focus on rehabilitation games or exergames (exercise games), i.e. those kind of games that help people with physical impairment to perform their physical therapy. Studies show [5] that the main issue with standard physical therapy is that, due to the monotony of the exercises, patients tend to lose interest in the therapy. As a consequence of this loss of interest, patients either perform their exercises irregularly or, in the worst case, quit the physical therapy. Since the aim of physical therapy is to help patients improving (or at least keeping stable) their physical functionality, either an early stopping of the therapy or not performing regularly the exercises can affect their quality of life and the ones of those who are close to them (e.g. their families). The introduction of new gaming input devices, such as Nintendo's Wii Remote™ and Microsoft's Kinect, that require the players to move more than their fingers in order to play a game and the subsequent development of games that involve physical activity, induced the researchers to consider the possibility of using videogames in order to perform physical therapy. Besides the hardware,

a major aspect that led researchers to study a possible application of videogames in rehabilitation is the inherent ability of games to draw the player's attention using a mix of entertainment and challenge. This aspect is really important in rehabilitation, since if a game encourages the patients to keep playing it, it will result in the patients performing regularly his physical therapy. Studies validated both the Wii Remote [9] and the Kinect [8] as suitable for the rehabilitation process and tested the effectiveness of some commercial games already developed [10-12]. This led to focus more on rehabilitation games. In particular, also considering the feedbacks of the therapists, were defined some game design rules [13] that a rehabilitation game should have. Those rules are a mix of classic game design rules that aim to design entertaining and challenging games and specific rules that validate the games as useful medical applications. We based on this set of rules to design our games.

We focused, in particular, on the hand rehabilitation of children affected by *Juvenile Idiopathic Arthritis* (JIA). JIA includes a set of rheumatoid diseases for which has not been defined a cause, yet. The main common symptom of this several types of arthritis is chronic joint inflammation. This inflammation begins before patients reach the age of sixteen and if the symptoms last from six weeks to three months, the disease is called chronic. JIA may involve one or many joints, and cause other symptoms such as fevers, rash and/or eye inflammation. A classification of six JIA onset types have been defined. *Systemic arthritis* affects the whole body and includes high fever, rash and inflammation of internal organs as symptoms. *Oligoarthritis* affects less than five joints. Symptoms include pain, stiffness or swelling in the joints. Also, an inflammation of the iris may occur. *Polyarthritis* affects five or more joints. *Psoriatic arthritis* consists of both arthritis and a skin disease called psoriasis or a family history of psoriasis in a parent or sibling. *Enthesitis-related arthritis* often involves attachments of ligaments as well as the spine. Children affected by this form of JIA may have joint pain without obvious swelling and suffer of back pain and stiffness. Finally, *Undifferentiated arthritis* includes syndromes that does not fit into any of the above categories or fit into more than one of the categories.

As said before, in this work we focused on the hand rehabilitation therapy, in particular on the exercises performed using the wrists. In order to do so we applied the iterative design approach, a methodology based on a cyclic process of prototyping, testing, analyzing, and refining of the games. We designed four different games following a set of both classical and specific game design rules. Our aim was to design a set of games that would be entertaining for everyone to play while helping patients performing their exercises. In order to do so, we designed different types of games, aiming to reach a wider range of people with different tastes and gaming background. In particular we designed four different types of game: a rhythm game, since games like Guitar Hero and similar proved this genre to be entertaining for a wide range of people; a casual game, similar to the famous Flappy Bird, that would appeal everyone with its simplicity and would serve as a virtual link to the other commercial non-medical games; a simple and intuitive arcade game, easy to play also for the younger patients; a 3D flight simulation game, that would provide a more mature experience, suitable also for older patients. We designed the gameplay of all the games to be as intuitive as possible. We wanted the patient to immediately understand how the game works and start playing It without tedious training sessions. In order to encourage the patient to focus on the performance, we added a scoring system that would function both as a visual feedback of the performance and as a reward for the correctness of the exercise. The possibility to compare the score between friends also adds a challenge factor that could encourage the patient to play more often and to focus even more on the game, resulting in more frequent and well-executed exercises. We also focused on the design of a set of helpful features for the therapists' analysis. We designed both a quantitative and a qualitative feedback. The former comes in the form of data collected during each performance. This data can be used by the therapist in order to analyze how the patient performed in an exercise, see if the therapy is helping the patient making progress in terms of increasing of the wrists' range of motion, and eventually modify the therapy focusing on specific movements. The qualitative feedback has been designed in the form of a replay mode that, using the data collected during an exercise, allows the therapist to see again how the patient performed the exercise in terms of physical positions of the

hands. This feature is useful, for example, to see how the patients perform the exercises when they are at home without the supervision of a therapist.

Finally, following the iterative design approach mentioned before, we performed a series of experimental sessions with the help of some patients of the Clinica Pediatrica G. e D. De Marchi. The aim of the first to sessions was to validate our design. We presented the games both to the patients and to the subjects, and collected their feedback as the subjects tested the games. The feedbacks were overall good, the subjects enjoyed playing to the game and the therapists were satisfied with the specific features that we implemented for the analysis and with the subjects' response. In particular they noted that the subjects were effortlessly performing exercises that they found boring during standard physical therapy. In the following experimental sessions we focused on how the subjects played to the games. We analyzed the data collected both in the form of hands' positions during the exercises and scores in the relative games, in order to see how the subjects adapted to the games and which games required more or less effort with respect to the others.

The document is organized as follows.

Chapter 2 is an overview of the games for rehabilitation. We discuss their aim, their features and present some developed games, focusing especially on those for hand rehabilitation.

In *Chapter 3* we present the *Juvenile Idiopathic Arthritis*, its causes, symptoms and treatment. We give a brief description of the polyarticular onset of JIA, since it is the one that is more likely to affect the hands. Finally, we present some exercises for hand rehabilitation.

Chapter 4 is about the games that we designed. We discuss the rules that we applied for the design of the games and how we later implemented it in the final games.

In *Chapter 5* we analyze the data retrieved during the experimental sessions. We describe the experimental setup of each session, the feedback received from both the therapists and the subjects and we present and comment the plots relative to the data collected.

Finally, in *Chapter 6* we draw our conclusions and present possible future developments and improvements of our work .

Chapter 2

State of the art

In this chapter we focus on serious gaming, in particular on the sub-genre specific for rehabilitation. We define what a serious game is and the process that led to the use of videogames for rehabilitation. Then we present some specific features and game design rules found in literature. Finally, we give an overview of the state of the art for hand rehabilitation games.

2.1 Games for rehabilitation

Rego et al. [1] define serious games as "games that allow the player to achieve a specific purpose using the entertainment and engagement component provided by the experience of the game". This specific purpose could be either an educational one [2] or a training one (e.g. military training [3]) or it could concern health issues [4]. Focused on this last environment are the games for health. They can be useful in diagnostics, prevention, advertising, training, fitness, rehabilitation, relaxation, etc. In our case, we focused on rehabilitation games. The aim of this kind of game is to help people who have impaired physical functions – as a consequence of a disease or some other harmful events – to perform their physical therapy throughout the rehabilitation progress.

Physical therapy is essential for the treatment of disabling pathologies, either chronic or acute; it usually consists of a series of task specific exercises which must be repeated over and over by the patient. In order for the patient to improve his/her physical condition, or at least to keep it stable, this therapy

must be performed frequently and for a long period of time, both at the hospital and (if it is possible) at home. The main issue with this approach is that patients tend to lose interest in doing repetitive exercises [5], compromising the effectiveness of the rehabilitation process. Indeed, patients find this repetitive exercises boring and frustrating, leading to a loss of motivation in keep performing the therapy. The issue worsen when the patients have to perform their exercises at home, without a therapist that supervises and encourages them.

The increasing popularity of videogames drew the attention of the researchers as a possible solution to this problem. Indeed, the success of videogames is due to their ability to entertain and engage people, motivating them to keep playing even for long periods of time. Researchers wanted to use this kind of engagement to encourage the patients to keep performing their therapy but, as they introduced virtual reality and videogames in the rehabilitation process, two limitations raised: the virtual reality systems were too expensive and the presence of technical experts was needed during therapy sessions [7]. This limitations prevented patients from performing the exercises whenever and wherever they wanted, thus affecting the regularity of the therapy.

The introduction of new input devices such as the Wii Remote, the Wii Balance Board, the EyeToy or the Kinect helped to overcome those limitations. Unlike classic controllers, these new devices required the players to move their whole body or part of it in order to play. The introduction of motion in playing proved to be entertaining for people [6]. Furthermore, the cost of the devices and their respective consoles (Nintendo Wii for the Wii Remote and Wii Balance Board, Sony Playstation 2 for the EyeToy and Microsoft Xbox 360 for the Kinect) was relatively cheap, making the games developed on these platforms more accessible. Studies were conducted that validated these instruments [8,9] as suitable for the rehabilitation process and tested the effectiveness of some off-the-shelf games (e.g Wii Sports [10], Wii Fit [11], EyeToy games [12]).

Off-the-shelf games proved to be not suitable for every patient because they require a speed and a range of movements that someone with physical

impairment cannot easily perform [13]. Hence the need to develop custom games and to define specific game design rules that would help developers in designing such games.

Burke et al. [13] discuss some features that a rehabilitation game should have and propose a couple others:

- it should provide precise data recording, in order for the therapist to clearly evaluate the exercise execution;
- it should provide to the therapist some kind of feedback relative to the level of the exercise;
- it should provide feedback to the players in order to measure their performance and their progress;
- it should handle both the rewarding side (i.e. giving quantifiable advantages for completing tasks successfully) and the failure side (i.e. exposing a recognizable disadvantage for poor gameplay) of the game in a way that keeps the patient effectively engaged;
- it should be challenging (but not frustrating) for the patient, this could be achieved by statically (e.g. using a level structure) or dynamically (i.e. while playing) adapting the game difficulty according to the patient's performances and abilities.

Borghese et al. [14] identify three key features in designing rehabilitation games: adaptation, monitoring, and real-time evaluation of the movements. The game should adapt its difficulty level to the abilities of the player, otherwise it would be either frustrating or tedious to play it. The performance of the player should be monitored, enforcing a correct execution of the rehabilitation movements. The player should receive feedbacks about his/her performance while playing, in order to understand when he/she is doing something wrong or right. Borghese et al. also remark the importance of designing rehabilitation games according to good game design principles in order to keep the player engaged. They state that "the patient, while exercising, should feel like a player, focused on having fun while playing the game".

Nixon and Howard [31] define a set of five game design principles useful to create engaging rehabilitation games. The first principle regards the in-game story. They say that an engaging story or context is crucial when trying to draw players into a play scenario. Also important is to design a user interface that is intuitive and easy to understand, since the player's concentration should be geared to how to beat the game, not how to learn its interface. Like Burke and Borghese, also Nixon and Howard remark the importance of providing immediate feedback to the player about something right or something wrong that he did while playing. Furthermore the game should encourage the player to explore and become familiar with his/her capabilities within the game; this helps the player gaining better control over his/her avatar. Finally, the player should be rewarded in order to keep him/her engaged in the game and to encourage him/her to play again, increasing his/her skills in order to get better rewards.

Mader et al. [32] assert that two fundamental features to the game designer's work are challenge and variability. These aspects are tightly related to the design of a therapeutic game. In order to keep the player motivated, the game has to inform him of his progression towards the goal. Also adapting the challenge level prevents anxiety or boredom in the player. Variability accounts for the motivation in the long run. As Mader et al. state "it is not enough to give the player the same task with an adapted difficulty level, we must also make him learn new patterns, gather new informations, explore the consequences of making different choices".

Mader et al. also propose a model to evaluate a therapeutic game. This model is based on three entities (the game, the therapy and the player) and on the relations between them. Starting from the therapy-player relation it is necessary to assess if the player has a particular condition that can be improved by the therapy. Then should be evaluated what is the context of play (e.g. at home, with a therapist), what is the place of the game within this context, which game features are therapeutic (e.g. the gameplay) and which game features are only motivational means. Finally, it should be evaluated if the player is able to play the game, if the game is enjoyable for the player and if the game safe for the patient's health.

2.2 Rehabilitation of upper limbs

In this section we will focus on the games developed for the rehabilitation of the upper limbs. We will provide some examples of games developed for this purpose, dividing them in two categories, non-hands-free games and hands-free games, depending on whether the patient has to hold something in his/her hands or not in order to play to the game.

2.2.1 Non-hands-free games

We define non-hands-free games as the ones that require the patient to handle a physical device in order to give the input to the game. We will briefly present some examples of games using each different input device.

Cifuentes-Zapien et al. [15] developed a racing game intended for the rehabilitation of children with cerebral palsy, using a robot as input device. The player can control the car's horizontal position by the pronation and supination motion. The goal of the game is to keep the car inside the track defined by the therapist. The player's trajectory is recorded and analyzed by a software. The game meets two of the requirements early discussed: it records the player exercises and gives to the therapist a feedback about the level of the exercises (since the therapist himself defines the track).

Godfrey [33] combined a robot designed to aid finger and thumb extension and flexion with two interactive virtual reality games to enhance user motivation in performing post-stroke rehabilitation exercises. The first game is a gate game in which subjects start in a flexed position and control two circles on the screen with finger and thumb movement. A moving wall with two open gates sweeps across the screen and the subject opens the fingers and thumb to pass each circle through its respective gate. The second game is an isometric squeeze and release exercise. The subjects' fingers and thumb are held open at half their range of motion and two circles are displayed on the screen, representing finger and thumb force production. The goal is to bring the circles into a central channel by flexing. Successful flexion then activates a wall that sweeps across the screen. Patients must then relax their flexors to avoid hitting

the wall. Both games have some defined parameters that allow to statically adapt the difficulty of the exercise to the player's performance.

Dunne et al. [34] designed three different games to be played with a multi-touch display by children affected by cerebral palsy. The first is a simple game in which the players need to maneuver a bone to a dog using their finger, avoiding the other characters and the obstacles in the game landscape. To increase motivation, the game rewards the player with extra points both for performing specific actions in the game environment, such as passing with the finger upon a star, and for keeping an upright position. The therapist can customize the levels in order to tailor the game to each patient's motor ability. In the second game, the patient must spell the animal shown in a bubble onscreen using the letter tiles scattered on the playing surface. Points are used as reward and feedback of the performance. There is also a negative feedback in the form of a penalty if the patient's compensatory movement exceeds the limits. Finally, the third game consists in catching butterflies with a jar. Also in this game a negative feedback is given to the player when he/she does something wrong. Furthermore the therapists can modify some parameters in order to customize the levels.

Karime et al. designed a racing game for the rehabilitation of people with injured wrists, in which the player has to challenge other cars [16]. It uses a stress ball integrated with sensors and actuators as input device. The aim of this game is to help the patients performing wrist rehabilitation at home, given the portability of the stress ball. The patient controls the car by grasping and rotating the ball which is integrated with a pressure sensor, an accelerometer, and two vibrator-motors that give a haptic feedback to the player. The system can be configured according to the level of the player and stores the sensory data in a database that could be used later on by the therapist to track the patient's progress. The system meets all of Burke's game design tips: it stores data of the exercise, it is customizable, hence giving the therapist an idea of the patient's level, and the nature of the game helps both giving the player a feedback of his progress and providing clear rewards.

Burke et al. [36] used a webcam and Augmented Reality (AR) techniques to create games for post-stroke rehabilitation. In doing so, they followed the game design rules defined in [13] and mentioned in Section 2.1. Burke et al. prototyped a game similar to Atari's Breakout. There is a row of bricks at the top of the playfield and the player has to clear them by rebounding a ball with a paddle, which they control by moving a real-world physical object with an AR marker attached. They also prototyped another game where the player has to put real objects on virtual shelves.

2.2.2 Hands-free games

In this section we provide some examples of games that don't require the patient to handle any devices with his/her hands. We consider also games designed to be played wearing gloves or attaching sensors to the hands.

Ustinova et al. [17] developed a game called Octopus which aims to improve arm-postural coordination in patients with traumatic brain injury. The goal of the game is to pop the bubbles blown by an octopus either with the left or the right hand. Patient-computer interaction is obtained using a 6-camera system for motion capture and hand avatars implemented with three reflective markers attached to each hand. The game gives a reward in the form of either a score or new characters when the bubbles are intercepted, it also helps the patient having a feedback of his/her performance; the game also keeps track of the patient's movements and analyzes his/her coordination.

Burke et al. [13] present a series of games which use different inputs. They made a game that uses magnetic sensor-based virtual reality equipment to track upper limb movements. It is a "whack a mole"-like game in which the player has to use his/her hand as a hammer and hit a mouse moving on the screen. They also developed a couple of games that use a webcam as the input and a marker (e.g. a glove) to keep track of the patient's hands movements. Both games require the patient to intercept an object on screen with a certain timing.

Friedman et al. [35] used a customized version of Frets on Fire, an open-source music game inspired by Guitar Hero, combined with an instrumented

glove and tested the effectiveness of this combination for post-stroke hand rehabilitation. Using an already existing game they had only to integrate its game design with some features that would provide some useful feedbacks for the therapists.

Also Zhang et al. [37] created a system for post-stroke hand rehabilitation that integrates videogames, AR and an instrumented glove. The game designed consists in a virtual piano that the patient can play with his fingers. They designed different levels of difficulty both to challenge the single patient and to take into account the different physical conditions of the patients. They also implemented a scoring module, both visual and audio feedbacks as performance indicators for the patient, and quantitative feedbacks for the therapist to analyze.

Chapter 3

Juvenile Idiopathic Arthritis and Polyarthritis

In this chapter we describe the rheumatic disease known as *Juvenile Idiopathic Arthritis*. At first, we discuss the disease cause, its development, the disease onset types, the clinical manifestations and the suggested therapy. Then, we focus in the specific on the *Polyarthritis* subset, since it can affect the small joints of the hands. Finally, we describe a set of exercises for hand and wrist rehabilitation that are the focus of this work.

3.1 Chronic arthritis in childhood

Juvenile Idiopathic Arthritis (JIA) identifies a set of autoimmune and inflammatory conditions that can develop in children ages sixteen and younger; if these conditions last for at least six weeks then the arthritis is considered chronic. About one child in every one thousand develops some type of juvenile arthritis [18].

Onset types	6
Course subtypes	1
Age at onset of arthritis	<16 yr
Duration of arthritis	= 6 wk
Includes JAS	Yes
Includes JPsA	Yes
Includes inflammatory bowel disease	Yes
Other diseases excluded	Yes

Table 3.1 ILAR criteria for classification of chronic arthritis of childhood [19] (JAS, juvenile ankylosing spondylitis; JPsA, juvenile psoriatic arthritis)

The term JIA was introduced in 1997 [19] and has largely supplanted the terms *Juvenile Chronic Arthritis* (JCA) and *Juvenile Rheumatoid Arthritis* (JRA) in referring to childhood chronic arthritis. Table 3.1 illustrates the criteria for classification of chronic arthritis of children as defined by the Pediatric Task Force of the International League of Associations for Rheumatology (ILAR). ILAR defined six onset types for JIA:

Systemic arthritis affects the whole body. Symptoms include high fever, often accompanied by rash that comes and goes, inflammation of internal organs as well as joints; also anemia and elevated white blood cell counts.

Oligoarthritis affects less than five joints. Symptoms include pain, stiffness or swelling in the joints. Also, an inflammation of the iris may occur regardless of active joint symptoms. Oligoarthritis can be persistent or extended depending on how many joints are ultimately involved.

Polyarthritis affects five or more joints. It can be RF-positive or RF-negative depending on the presence of the Rheumatoid Factor. We will describe it further in Section 3.2.

Psoriatic arthritis consists of both arthritis and a skin disease called psoriasis or a family history of psoriasis in a parent or sibling.

Enthesitis-related arthritis often involves attachments of ligaments as well as the spine. Children affected by this form of JIA may have joint pain without obvious swelling and suffer of back pain and stiffness.

Undifferentiated arthritis includes syndromes that does not fit into any of the above categories or fit into more than one of the categories.

3.1.1 Etiopathogenesis and clinical manifestations

As the term “idiopathic” would suggest, the set of factors coming together to cause JIA (the etiology) is unknown, although it is almost certainly multifactorial and probably differs from one onset type to another. Several onset types share common elements. For instance, in *Oligoarthritis* and *Polyarthritis* of type RF-positive is common the presence of autoantibodies –

the proteins responsible for autoimmune. *Polyarthritis* of type RF-negative, and to some extent *Psoriatic arthritis*, have less tendency to autoantibody formation but have strong association with polymorphism at the histocompatibility locus (i.e. the positions on a chromosome occupied by a complex of genes that govern several tissue antigens; they are checked by the organism in order to recognize its own healthy cells or tissues and not attack them). On the other hand, *Systemic arthritis* isn't characterized neither by the presence of autoantibodies nor a strong genetic predisposition and may be considered an autoinflammatory disease.

The origin of the disease (its pathogenesis) has not yet been identified as JIA involves several factors such as genetic predisposition, disordered immune responses, its clinical heterogeneity, the difference in sex ratio (which sex is more affected) depending on the onset type (there is a much higher prevalence of *Oligoarthritis*, *Polyarthritis* and *Psoriatic arthritis* in girls, while *Enthesitis-related arthritis* has a bigger incidence in boys), the presence of peak ages at onset for some onset types (e.g. *Oligoarthritis*), and the association of extra-articular complications.

The hypothesis that the immune system is intimately involved in pathogenesis is supported by a number of observations [19]: the abundant evidence of altered immunity, the association between specific immunodeficiencies and rheumatic diseases, including chronic arthritis, a close relationship between immune reactivity and inflammation, the hallmark of arthritis. Studies have recognized also the importance of the innate immune system ("a subsystem of the overall immune system that comprises the cells and mechanisms that defend the host from infection by other organisms in a non-specific manner" [20]) in JIA pathogenesis [19]. There is no evidence that autoantibodies participate directly in disease pathogenesis; they may be produced as a result of inflammation and tissue damage. Given the differences in sex ratio and the presence of characteristic pre-adolescent or post-adolescent peaks in incidence of specific onset types, reproductive hormones may play an important role in pathogenesis.

JIA is not considered hereditary and rarely involves more than one family member. Some individuals may have a genetic tendency to develop JIA, but the disease appears only after exposure to an infection, physical trauma or other unknown trigger.

Characteristics of the Inflamed Joint
Pain
Stiffness
Swelling
Loss of function
Heat
Erythema

Table 3.2 Characteristics of the Inflamed Joint

Extraarticular Manifestations
Anorexia
Weight loss
Generalized growth failure
Localized growth disturbances
Delayed sexual maturation
Osteopenia
Rash (systemic-onset)
Subcutaneous nodules
Cutaneous vasculitis
Atrophy and weakness of muscles

Table 3.3 Extraarticular Manifestations

Clinical manifestations of the disease (Table 3.2 and 3.3) include a set of symptoms that may vary from an onset type to another. Many children are affected by anorexia, weight loss and growth failure. Fatigue is a common symptom in children with *Polyarthritis* or *Systemic arthritis*, especially at onset and during periods of poor disease control; inflamed joints are also characteristics of arthritis. Signs of inflammation include swelling, pain, heat, loss of function, and sometimes erythema. Joint stiffness is also present, often described by the parents as slowness or awkwardness in the gait [19]. Active or passive motion of inflamed joints causes pain, especially at the extremes of the range of motion. Large joints are most frequently involved, but small joints of hands and feet can also be affected, especially in polyarticular-onset

disease. The temporomandibular joint and to the cervical, thoracic, and lumbosacral spine are also affected in some onsets. Localized growth disturbances may occur, resulting in either overgrowth of a limb or diminished length. An example of localized growth not affecting limbs that can occur is micrognathia, a condition where the jaw is undersized. JIA can also affect sexual maturation, resulting in delayed puberty and secondary sexual characteristics. Osteopenia, a condition in which bone mineral density is lower than normal, is a symptom of JIA as well and it is a potentially major determinant of functional outcome in young adults who have had chronic arthritis as children. Skin and subcutaneous symptoms include rash (in systemic-onset disease) and a dark discoloration of the skin over the proximal interphalangeal joints, particularly in children with involvement of the hands. Rarer are subcutaneous rheumatoid nodules and cutaneous vasculitis, a group of disorders that destroy blood vessels by inflammation. Atrophy and weakness of muscles around inflamed joints is characteristic and is often accompanied by a shortening of the muscles and tendons that results in flexion contractures.

Immediate	***Long-term***
Relieve discomfort	Achieve disease remission
Preserve function	Minimize side effects of disease and treatment
Prevent deformities	Promote normal growth and development
Control inflammation	Rehabilitate
	Educate

Table 3.4 Objectives of the treatment of chronic arthritis in children [19]

3.1.2 Treatment

A cure to chronic arthritis has not yet been found, but fortunately there are many cases of spontaneous remission. Accordingly, the main goal of therapy is to induce remission while controlling pain and preserving range of motion,

muscle strength and function, to manage systemic complications, and to facilitate normal nutrition, growth, and physical and psychological development [19] (Table 3.4). Most children with chronic arthritis require a combination of pharmacological, physical, and psychosocial approaches. A main priority is to promote normal psychological and social development, in order for the child not to feel left out. Affected children should be involved in the same activities as the healthy ones, at their own level. Activities with other kids affected by chronic arthritis can also help the children to realize that they are not the only ones with arthritis.

Regarding the disease physical treatment, there are four main aspects:

- **Pharmacological management:** the treatment should begin as soon as the disease is discovered; the sooner it starts, the less likely it is that there will be permanent sequelae.
- **Nutrition:** together with development, and growth are important aspects of long-term management. Nutritional and vitamin supplementation are often indicated.
- **Physical and occupational therapy:** their objectives are to minimize pain, maintain and restore function, and prevent deformity and disability.
- **Orthopedic surgery:** it has a limited role in management of chronic arthritis in young children. In the older children it could be helpful in the treatment of joint contractures, dislocations, or joint replacement.

3.2 Polyarthritis

Polyarthritis is the JIA onset type that affects more than four joints in the first 6 months of disease. There are two kinds of *Polyarthritis*: *RF-negative Polyarthritis* if tests for the rheumatoid factor (RF) are negative and *RF-positive Polyarthritis* if tests are positive on two occasions at least three months apart.

The onset age distribution of *RF-negative Polyarthritis* has one peak at one to three years of age and another encompassing later childhood and adolescence

(although it can begin at any age before sixteen). *RF-negative Polyarthritis* affects girls approximately four times more frequently than boys [19]. *RF-positive Polyarthritis* average age at onset is nine to eleven years; range is 1.5 to fifteen years. Affected girls outnumber boys from four to thirteen to one in large series [19].

Table 3.5 and 3.6 show *RF-negative Polyarthritis* clinical manifestations and the RF-positive ones.

Articular disease	***Systemic manifestations (unusual)***	***Extraarticular manifestations***
Stiffness	Fatigue	Subcutaneous nodules (rarely)
Swollen joints	Growth failure	Uveitis
Reduced range of motion	Low-grade fever	Higher blood pressure and heart rates
Higher prevalence of growth changes		

Table 3.5 RF-negative Polyarthritis clinical manifestations

Articular disease	***Systemic manifestations***	***Extraarticular manifestations***
Limited range of motion	Fatigue	Rheumatoid nodules
Possible deformity of hands and feet	Weight loss	Felty Syndrome (rarely)
		Vasculitis (rarely)
		Rheumatoid lung (rarely)
		Aortic insufficiency (rarely)

Table 3.6 RF-positive Polyarthritis clinical manifestations

Children affected by *RF-negative Polyarthritis* suffer mainly from articular disease; extra-articular features are infrequent and less severe than those caused by *RF-positive Polyarthritis*. Most commonly affected joints are the

knees, wrists and ankles; children affected by the RF-negative onset are also more likely to have temporomandibular joint involvement than those who are RF-positive. In children with *RF-negative Polyarthritis*, the number of affected joints tends to be less and the pattern of involvement more asymmetrical than in *RF-positive Polyarthritis*. In RF-negative disease, involvement of wrists and small joints of the hands is less frequent than in RF-positive disease. Furthermore, those affected by *RF-negative Polyarthritis* are more likely to be subject to growth change than the ones with RF-positive disease, since the RF-negative disease tends to have its onset at a younger age.

As for the treatment, the rules described in Section 3.1 apply to those disease too.

3.3 Physical therapy

As discussed in the previous section, one of the main symptoms of JIA is joint inflammation. If this kind of symptom is not treated, it can result in loss of articular functionality, making the patient's everyday tasks more difficult and thus worsening his/her quality of life. The main goal of physical therapy is not that of healing the inflammation, but to help the patient coping with the effects of the inflammation and therefore improving the patient's self-sufficiency and quality of life (and those of his/her family, as well). The therapists guides the child and his/her family in the process of understanding which are his/her moving capabilities both in spontaneous activities and in sport activities. During this process, the therapist also helps reducing the patient's fear of pain and the family's tendency to overprotect the child; these behaviors can indeed penalize a good natural progression. The physical therapy should be customized for each patient and should take place both at the hospital (or another designated structure) and at home. In combination with this monitored physical therapy, therapists recommend also to play some sports. Indeed, a main aspect of physical therapy is allowing the child to live a life as normal as possible, and sports can help him/her not feeling different from the other children.

3.3.1 Wrist exercises

As said, the main part of physical therapy is performed at the hospital or at home. It consists of a series of repetitive exercises specific for each joint. There are exercises for both large joints, such as the knees or the shoulders, and small joints, such as those of the hand. In this work we focused on the exercises for hand rehabilitation, especially on those that involve the wrists. The two main exercises are the wrist extension/flexion and the radial/ulnar deviation.

The extension and flexion exercise is very important, since it involves one of the two main wrist movements (Figure 3.1). It can be done with the hand either opened or closed, palm down. The forearm can be laid on a pillow or on a plane surface and it must not move during the exercise. The patient has to bend the wrist to move his/her hand upward, then lower his/her hand.

Figure 3.1 Wrist extension and flexion [21]

The other main wrist movement is the deviation; it can be ulnar o radial depending on which side the hand moves (Figure 3.2). The exercise is carried out on a perpendicular axis in respect to the flexion/extension exercise. Again hand can be either opened or closed, palm down. The patient has to slowly bend the wrist as far as he/her can from side to side.

Figure 3.2 Wrist radial and ulnar deviation [21]

3.3.2 Other exercises

For further information we describe a set of exercises for hand rehabilitation. The first exercise that we present is the tendon glide (Figure 3.3). Starting position: open hand, fingers and thumb pointing straight up, relaxed wrist following the line of fingers and thumb. The patient has to curl his/her fingers so that the top two joints in them are bent, and the fingers wrap down. The fingertips should touch or be near the base of the fingers. Next the patient has to make a fist by bending his/her knuckles. Then he/she has to unwind his/her fingers slightly so that the fingertips can touch the base of the palm. Finally he/she can move back to the starting position, with fingers and thumb pointing up.

Figure 3.3 Tendon glides [22]

Specific for the thumb are the flexion/extension (Figure 3.4) and abduction/adduction (Figure 3.5) exercises. The former exercise consists in bending the thumb downward and across the palm, so that the thumb touches the base of the little finger, and then straightening it.

Figure 3.4 Thumb flexion/extension [22]

The latter consists in pulling the thumb away from the palm as far as the patient can and then slowly move the thumb back to the starting position (open hand, fingers and thumb pointing straight up, thumb resting against the index).

Figure 3.5 Thumb abduction/adduction [22]

The finger opposition exercise (Figure 3.6), instead, is for all the fingers of the hand. Starting position: open hand, fingers and thumb pointing straight up, relaxed wrist following the line of the fingers and thumb. The patient has to touch his/her thumb to each finger, one finger at a time. The other fingers has to stay straight and pointing up as much as possible.

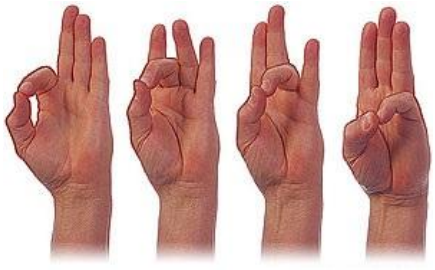

Figure 3.6 Finger opposition [22]

Finger extension exercise (Figure 3.7) also involves all the fingers of the hand. Starting position: hand flat on a table, palm down. The patient lifts and then lower one finger at a time off the table.

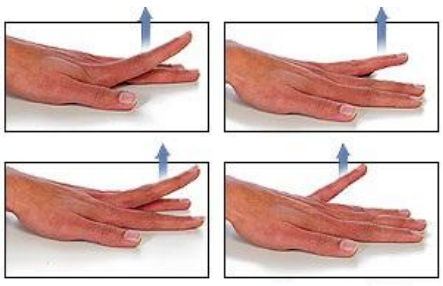

Figure 3.7 Finger extension 1 [23]

The last exercise is for finger extension too, and it is illustrated in Figure 3.8a. Starting position: fingers and thumb pointing straight up, palm down. The patient tries to pull each finger away from the adjacent ones as far as he/she can, then slowly returns to the starting position. A variant of the exercise consists in putting a small object between two fingers and have the patient trying to squeeze it (Figure 3.8b).

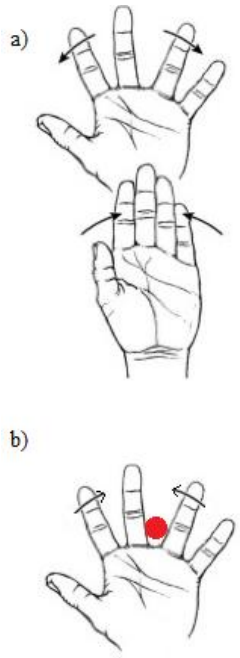

Figure 3.8 Finger extension 2 [24]

Chapter 4

Designing rehabilitation games for JIA

4.1 Designing rehabilitation games

Usually, when people think about games that has such a specific and important purpose as rehabilitation, they do not consider them as real games, but more as medical applications disguised as games. This impression leads people to underestimate these games' potential and, more important, can result in a loss of interest from the patients in this non-standard therapy.

An important step forward, for serious games in general and rehabilitation games in particular, has been made by the introduction of new input interfaces, such as the Wii Remote and the Kinect. Using this new hardware, general public experienced new kind of games that did not focus only on pure entertainment. This benefited rehabilitation games in two ways: on one hand it drew the researchers' attention to this different kind of therapy, on the other hand it made the line separating real games from serious games smaller. To erase that thin line, hardware alone is not enough, it is necessary to create a game with the idea that everyone can play it and enjoy doing it. Obviously, the main focus remains, in our case, on rehabilitation, but that approach allows us to create games that effectively draw the patient's attention and, taking advantage of the typical addictiveness of videogames, help him/her to carry on with his/her therapy.

In order to achieve all of this, we need to apply those general game design rules that characterize every game, and add to those rules some specific ones for serious games in general and rehabilitation games in particular. It is on this set of rules that we focused in order to design our games.

The key point in game design is the entertainment. This aspect is fundamental, because the ability of a game to draw your attention and make you want to keep playing it is what differentiate the good games from the bad ones. The entertaining factor is even more important when dealing with rehabilitation games. As seen in Chapter 2, the main issue affecting patients who are going through a rehabilitation process is that of the lack of continuity due to the monotony of the exercises. Indeed, physical therapy consists of a set of repetitive exercises that, in the long term, may result as boring. Because of this, many patients tend to either to quit the physical therapy or to perform it irregularly, affecting the rehabilitation process and, consequently, their quality of life. Hence the need to create games that draw the patient's attention, encouraging him/her to exercise as much as possible.

However, creating an entertaining game is not that simple. One of the main requirements is to balance the gameplay in order to make a game that is neither too easy, risking the patient to get bored, nor too difficult, hence frustrating: when the player either loses or performs bad, he/she has to feel like he/she was almost there, like if he/she plays once more he can perform better. In both cases, the banal game and the frustrating game, the patient may lose interest in the game and quit the therapy, and we don't want that to happen.

Gameplay is not the only factor affecting the entertainment. Another important aspect is the feedback that the game gives to the player regarding his/her performance. A good way of designing such feedback is in terms of a rewarding system that encourages the player to perform better in order to increase the received reward.

Starting from these observations we designed are games trying to make them as much entertaining as possible. We opted for a really intuitive gameplay, that way the patient can quickly play the game without long training sessions. We also designed a balanced reward system that rewards a correct performance

but, at the same time, does not penalize too much the possible errors. This reward system has been rendered by assigning a score to the player performance. This score is incremented every time the player does something good, but it is not decreased when he/she makes a mistake. In this way, a patient that has done something good and a lot of mistakes won't see his efforts nullified by a zero points score, instead he/she will have a score comparable with those of his/her friends. The possibility itself to compare scores with the friends can, indeed, encourage the patient to put more effort in the exercises, hence influencing both the correctness of the performance and the longevity of the game.

As seen in Chapter 3, children affected by JIA are both male and female and the difference of age between them can be substantial. Since different people, in different maturation states, have different tastes and enjoy different things, we diversified our offer, designing different types of games. We tried to reach a range as wide as possible of patients and to do so we designed four different standalone games, with some common features that now we are going to discuss.

The first genre on which we focused was that of musical games or rhythm games. The success of games like Guitar Hero [27], and other similar ones, has proved how a variety of people enjoy playing this kind of games, regardless of sex, age or gaming background. Their ability to turn a passion of a lot of people into a game, transforming a simple mechanical gesture such as that of tapping to the rhythm while listening to the music into something enjoyable, is the core of this success. It is starting from these observations that we decided to create this kind of game. Moreover, having the chance to create hundreds of tracks, the game longevity increases dramatically (just think to all the expansions made for the Guitar Hero or Rock Band games).

The second type of game on which we focused was that of casual game. This kind of games are very intuitive and are aimed to reach people that does not have a strong gaming background. Their main features are a simple and intuitive gameplay, that doesn't require too much effort, a clean graphic style and, usually, brief duration. We chose to design this kind of game because, as

the spread of smartphones increases, almost everyone is stumbled upon this games. In particular, we designed a Flappy Bird-like [28] game. For the ones who do not know the original game, the aim of Flappy Bird is to make a bird jump across a series of pipes by tapping the screen with the finger. Even though from this description it could sound like an easy game, it is instead quite difficult, and the couple easy gameplay-difficult game makes it rather engaging. That is why we chose this specific game. Furthermore, being it a rather famous game, it could help the patient in perceiving the game as a real game, also played by his/her friends, and not a medical application.

The third game that we designed is an arcade game. It goes back to the old arcade games where you had to move the character from left to right in order to catch (or avoid) some objects that moved towards it. In our case, the player moves from left to right, and vice versa, a skier who is running down a track and has to pass through a series of flags. This game, too, has a very simple and intuitive gameplay, since the connection between the hand's movement and the movement of the character on the screen is quite immediate. We chose this kind of arcade game in particular because it allows the patient to work well on the range and on the alternation of movement.

The fourth and last game has been designed to be more entertaining also for older children. It is a 3D flight simulator. Starting from the graphic, more complex than those of the other three games, to the environment where the game takes place, we tried to design a game that would attract people who wanted a more mature experience rather than that offered by the casual game or the arcade one. In the game, the patient pilots an airplane by moving the hands; the aim is to make the plane pass through a series of circles (something similar to Aironauts [29], for the ones who remember it, or the Quidditch sessions in the Harry Potter games [30]). The possibility to create different paths, developed an a potentially vast area, allows to live every time a different game experience, that could be adapted to the player's level of challenge.

Providing four different games to play to is also useful for each patient in order to keep him/her motivated and engaged by varying the virtual

environment, instead of performing the same exercise in the same game over and over.

As said before, for each game has been defined a rewarding system that increases the score when the player does something good, but does not decrease it when he/she makes a mistake (except for the Flappy Bird-like game, where, if you hit a pipe, the game ends). Given that the main reason for choosing this solution is not frustrating the player, there are also specific reasons for each game. For the rhythm game, we took into account the intrinsic difficulty of the game and the fact that some people have poor sense of rhythm (not depending on their health status). If the patient hits correctly only a small percentage of notes and the game decrease his score for every missed note, he/she will feel like all his efforts were for nothing and will quit the game. Regarding the arcade game, maybe a patient can perform only slow movements, due to joint stiffness or pain, so it could happen that he could not be able to reach in time a couple of flags if they are too far from the previous couple; but this is not his/her fault, so it is unfair to penalize him/her. Same goes for the plane simulator. Maybe, when creating a path, an object could be set too far away for a patient to reach it with his/her limited range of motion. Also in this case, this is not the patient's fault, so it is unfair to decrease his/her score.

The scoring system is not only a good feedback for the patient, but it is also a useful first qualitative feedback for the therapist about the patient's performance. In fact, the therapist, knowing the number of obstacles in a game and the patient's score can infer whether the patient performed well or not.

As you can see, except for the last two paragraphs, until now we just discussed about pure game design, without mentioning the rehabilitation features. That is because, in designing the games we wanted our will to create real games to show through. We did not want to make special games for special kids, but games for kids. Games that a kid would want to play either alone or with his friends.

Obviously, while designing the games we had to take into account also the rehabilitation side of the applications. To do so, we based on the game design

rules find in the literature (Chapter 2). Four are the key point on which we focused: the ability of the game to adapt to the capabilities of the patient, the possibility for the therapists to create custom game levels, the need to save every information about how the patient performs during the exercises and the possibility to see again the exercise carried out by the patient.

Designing the movement management we had to take into account the different limitations of the patients. Keeping the main objective to create games that could be played by everyone, we designed a movement system that allows everyone to play and have good results regardless of his ranges of motion. In some games, like the plain simulator one, it has been obtained by adapting the difficulty of the track to the player's range of motion. In others, like the arcade game, we adapted the character's movement to the player's limitations, allowing everyone to reach the extremes of the track regardless of the range of motion.

Regarding the level design, we tried to make the movements to be performed the more uniform as possible. We designed two ways of creating the levels: a random one and a custom one. The custom creation gives the therapist the freedom to create a path that resembles the specific movement that he/she wants the player to perform. The therapist has to simply do the exercise once and the system will track and save his/her movements and create the associated path. Using the custom creation, the therapist can create both more generic paths and paths specific for a certain patient or group of patients. The random creation, instead, is automated. The therapists sets some parameters, like the duration of the exercise or the range of motion (expressed in terms of difficulty), and the system creates a random uniform path. Using the level creation modules, the therapist can statically adapt the difficulty of the game to the patients' ability, keeping them motivated to play to the games.

One of the benefits of using rehabilitation games for physical therapy is that they allow the therapist to retrieve data in order to analyze the patient's performance. Thanks to these data, indeed, it is possible both to keep track of the patient's progress and to have a both a quantitative and qualitative feedback about his/her movement capabilities. For this reason we chose to

save two kinds of information: the patient's range of motion and every position of the hands during the game. The first information is useful to see if the therapy is helping the patient in reducing his/her movement limitations over time, while the second is useful for the therapist to analyze the patient's movements in order to decide on which kind of movement they have to work more.

The data saved during the exercise has also been used in the designing of a replay mode that would allow the therapists to see how the patient performed the exercise. This feature is useful both because it gives the chance to the therapist to see exercises performed at home by the patient, so without the therapist being there, and also because it provides a qualitative feedback more immediate than the plots, that could be watched and analyzed over and over again. It helps the therapist to promptly find possible mistakes in he exercises and to directly show them to the patient in order to let him understand what he did wrong.

The last two features (saved data and replay mode) are crucial for the therapists because they help them to verify the effectiveness of the treatment, to keep track of the patient's progress and to define possible improvements to the therapy.

4.2 Preliminary meeting and requirements

During the first meeting, the therapists introduced us to how the physical therapy for JIA works. After a brief explanation of how the inflammation affects the functionality of the joints and which are the main goals of physical therapy (see Section 3.3), the therapists showed us a set of exercises with the help of a couple of patients. They showed us exercises for both the upper and lower limbs, involving large joints such as the knee and the hip joint, and small joints, e.g. the ones of the wrists and the fingers.

We divided the set of exercises in two groups: those for the upper limbs and those for the lower limbs. We decided to focus on the upper limbs - on the hands in particular - and we searched for suitable input devices that would

allow us to easily recreate in a virtual environment the movements required by the exercises.

The device that drew our attention is the *Leap Motion Controller* (LMC) [25] (Figure 4.1). LMC is a small device (height 1,27 cm, width 3 cm, depth 8 cm) that connects to a PC via USB cable. The Leap Motion system recognizes and tracks hands, fingers and finger-like tools. The device operates in an intimate proximity with high precision (0.01mm) and tracking frame rate and reports discrete positions, gestures, and motion.

Figure 4.1 Leap Motion Controller

The Leap Motion controller uses optical sensors and infrared light. The sensors are directed along the y-axis – upward when the controller is in its standard operating position (facing upward) – and have a field of view of about 150 degrees (Figure 4.2). The effective range of the Leap Motion Controller extends from approximately 25 to 600 millimeters above the device [26]. The Leap Motion software combines its sensor data with an internal model of the human hand to help cope with challenging tracking conditions.

Figure 4.2 LMC's view of the hands

Figure 4.3 shows how LMC sees the hands. It can track both left and right hands and forearms at the same time; for each hand it can track every finger and the relative phalanges. Actually a real thumb has one less bone than the other fingers, but, for programming reasons, the Leap Motion thumb model includes a zero-length metacarpal bone so that the thumb has the same number of bones at the same indexes as the other fingers. Using the API we can retrieve the position and rotation of the forearm, the palm, and each bone in the fingers, according to the coordinate system in Figure 4.4.

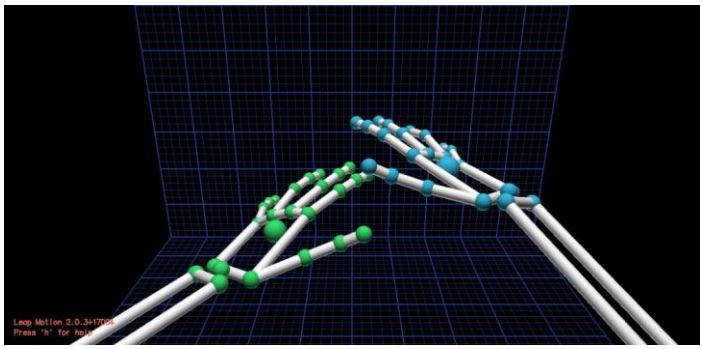

Figure 4.3 Leap Motion Diagnostic Visualizer

The Leap Motion system employs a right-handed Cartesian coordinate system. The origin is centered at the top of the Leap Motion Controller. The x- and z-axes lie in the horizontal plane, with the x-axis running parallel to the long edge of the device. The y-axis is vertical, with positive values increasing upwards (in contrast to the downward orientation of most computer graphics coordinate systems). The z-axis has positive values increasing toward the user [26].

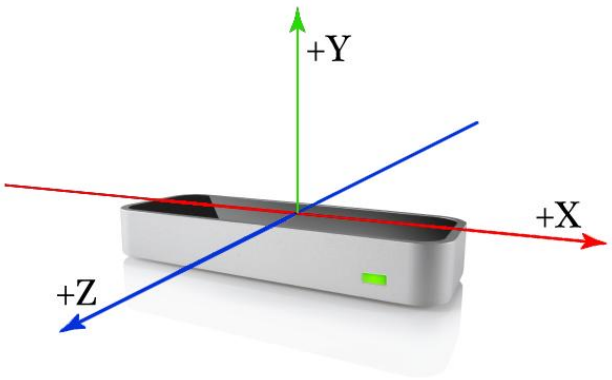

Figure 4.4 LMC right-handed coordinate system

The Leap Motion software also recognizes certain movement patterns as gestures which could indicate a user intent or command. The movement patterns recognized by the Leap Motion software are: the circle gesture (a finger tracing a circle, Figure 4.5a), the swipe gesture (a long, linear movement of a hand and its fingers, Figure 4.5b), the key tap gesture (a tapping movement by a finger as if tapping a keyboard key, Figure 4.5c), the screen tap gesture (a tapping movement by the finger as if tapping a vertical computer screen, Figure 4.5d).

In the end, we decided to use the LMC as input device for five main reasons:

- the player does not have to hold any physical device with his hands, so he can move freely and perform better exercises;
- the precision of the device allows us to perform a better tracking of the hand movements;
- the device have a high portability, given its small dimensions, so the patient can do his/her exercises wherever he/she wants (presuming that he/she has access to a PC);
- it is easy to install and intuitive to use, so there is no need for expert support;
- it is relatively cheap (89.99€), so almost everyone can afford it.

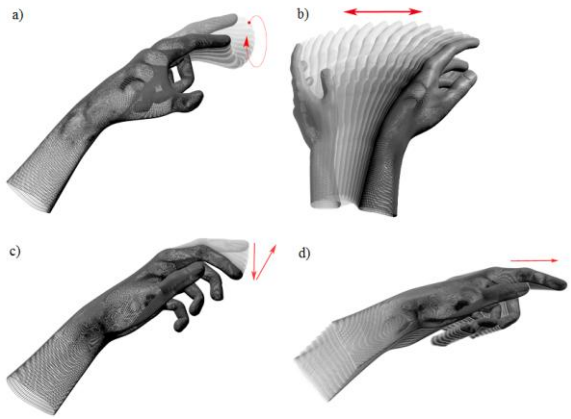

Figure 4.5 Gestures recognized by the LMC

After some testing with the device, we proposed to the therapists a set of games. For the reasons discussed in the previous section, we designed four

different types of games, trying to make them appealing for a wide range of people.

We also asked the therapists which features would have been useful for their work, in order to implement them in the games. What came out was similar to the set of features defined in literature (Chapter 2) and to the rules of game design upon which we based our games (Section 4.1). The first thing that the therapists mentioned was the possibility to have a quantitative feedback from the games, i.e. collect data of the patient's movements. The main interest of the therapists was to have information about the wrist's extension, flexion and deviation degrees throughout the game.

A qualitative feedback was required as well, in terms of being able of examine how the patient does an exercise. This feature came out as a consequence of the possibility for the patient to perform the exercises at home, without the therapists' supervision. Hence, a way of displaying the patient's hand movements during the exercise was necessary in order to assess its correctness.

4.3 Main application and games

In this section we present the final versions of the games, developed following the results of our iterative design approach. This design methodology is based on a cyclic process of prototyping, testing, analyzing and refining of the product. We validated our designs with the results of the experimental sessions, both in terms of qualitative feedbacks (from therapists and subjects) and quantitative feedbacks (the data retrieved during these sessions). Thanks to the iterative design we were able to gradually improve our games, developing the final versions presented in this section.

We developed four different games. Right now they are all part of a single application, but they can be easily divided and can work as standalone. Figure 4.6 illustrates the architecture of the system. The LMC is the physical interface between the user and the PC. It tracks the user's hand movements and sends them as input to the application.

The application is divided in two parts, one for the therapist and one for the player. In his/her section, the therapist can create custom levels for each game. In this way he/she can create exercises specific for each patient. The therapist can create the levels either manually or randomly. In the first case he has to perform the exercise that will be recorded and stored. In the second case he can simply edit some parameters and then the application will automatically generate a random level.

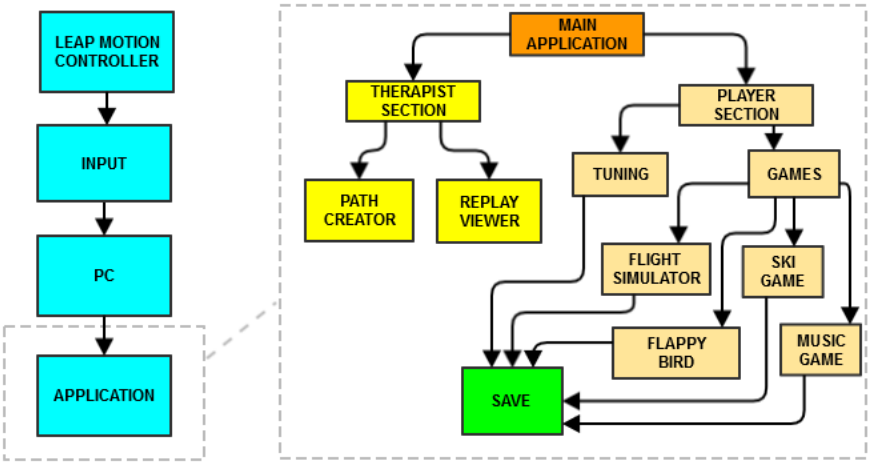

Figure 4.6 System architecture

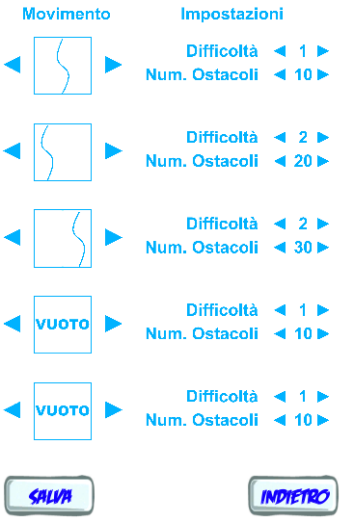

Figure 4.7 Random path generator

Figure 4.7 shows one of the games' random path editor. The therapist can define the number of obstacles in the game (influencing the duration of the exercise) and the difficulty of the exercise (i.e. the range of the movement to

perform in respect to the maximum range of motion of the patient). In the case of Figure 4.7 the therapist can also decide to focus more on one side of the movement or the other.

In its dedicated section, the therapist can also see the replays of the exercises performed by the patients. Figure 4.7 shows an example of what the therapist can see in the replay mode. In the background plays the replay of match, while in a corner are shown the hands movements throughout the game.

Figure 4.8 Replay mode

The player's section of the game is divided in two phases. If the player is playing for the first time or if too much time has passed from the last tuning session, he/she has to go through a tuning session.

Figure 4.9 Tuning session (translation : "Bend upwards your wrists as much as you can and keep that position for five seconds")

The aim of this session is to store information about the patient's range of motion. We ask the patient to reach the maximum of his range of motion in flexion, extension, radial and ulnar deviation (Figure 4.8) and we save those values. This information is useful both for the therapist, because he/she can analyze the patient's level and his/her progress, and for the application, in fact it is used to adapt the game to the patient's capabilities, so he/she does not get frustrated.

After the ranges of motion are stores, the player can play the available games. Each player has his/her own profile where all his/her information is stored (name, ranges of motion, last time that he/she performed the tuning session, highscores). During the exercises all the hands movements are saved to a file. This data is used in the replay mode to recreate the player's performance, but can also be analyzed (as we do in Chapter 5).

As for the games, given the different ages and interests of the patients we developed a variety of games that we believe could be appealing to a wide range of players. One of the available games is a rhythm game, like Guitar Hero. The reasons for this choice are quite simple: tapping something to the rhythm of the music is quite mechanical (even if not always simple), everybody loves music and Guitar Hero and the other similar rhythm games proved that this genre is appealing for a different kinds of people. The second game is a casual game. We developed a flappy bird-like game, because it is intuitive and quite famous, so it gives the patient the idea that he/she is playing a real game, like the ones that everyone else play. The third is an arcade game. The player controls a skier that has to pass through a series of flags as in a slalom. It is similar to those old portable games where you had to avoid objects coming at your character by moving it to the left and to the right. Finally, with the fourth game we tried to make something a bit more mature for children a little bit older. It is a 3D flight simulator game. In this game the player drives a plane moving his hands and has to pass through a series of circles.

In the next sections we briefly describe each games, showing some screenshots for a better understanding.

4.2.1 Rhythm game

The aim of this game is to help patients performing wrist flexion exercises. While music plays in the background, buttons fall from above and the player has to push them at the right time. Figure 4.10 shows the interface of the game. There are two lines, one for each hand; the buttons come down on each line and the player has to press them using the correct hand while they are in the relative circle. The pressing is achieved by the flexion motion, keeping the forearm still, horizontal, and quickly bending down the wrist, as if the player is trying to push a physical button like the ones in quiz shows.

Figure 4.10 Rhythm game

A certain amount of points is given to the player for each button pressed correctly. No points are assigned either for not pressing a button or for pressing when there is no button in the circle. We adopted this scoring method instead of penalizing the player for bad timing, because, given the effects of the disease on the motion, it is not easy for the patient to have perfect timing (even some healthy people are bad at timing games) so it could be frustrating to lose all the points earned, and we don't want the player to get frustrated and quit exercising.

Right now the button positions are defined by the developer. Future implementations will include the possibility for the therapist to create a custom button track for each song.

4.2.2 Flappy Bird-like game

This game involves both wrist flexion and extension. The player has to make the character pass through a series of pipes (Figure 4.11) until the end of the track. The game is played with one hand at a time. We implemented two ways of moving the character, one involving only the extension movement, the other involving both extension and flexion movements. The first game mode is similar to the original Flappy Bird game. In the original game, the player has to tap on the screen in order to make the character jump at the correct height to pass through the pipes. This action is recreated in our game using a movement similar to the one used in the rhythm game to press the buttons, but in the opposite direction. The player has to quickly bend up the wrist to make the character jump, as if he/she was trying to create a gust of wind beneath the character.

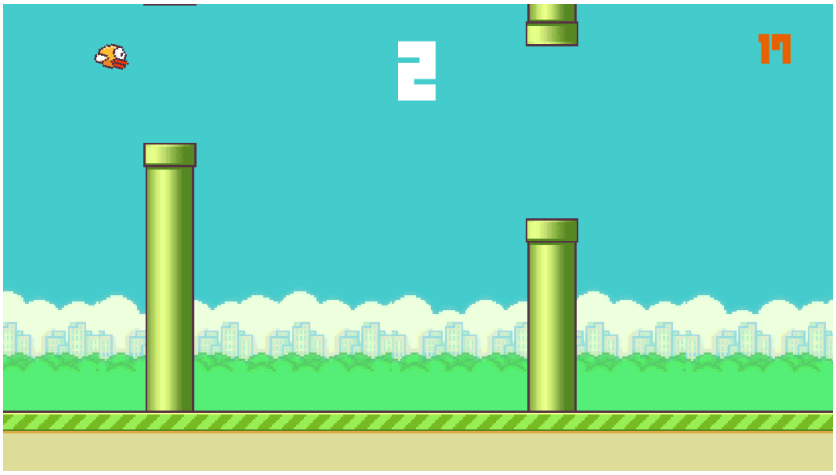

Figure 4.11 Flappy Bird-like game

In the second game mode the player can directly control the character's height using his wrist. Keeping the hand parallel to the ground will make the character stand in the center of the screen. Bending up the wrist will make the character go up, while bending the wrist down will make it go down. The height reached by the character depends on the angle reached by the wrist. The closer the wrist gets to one of the extremes of its range of motion, the higher or lower the character flies.

If the character touches one of the pipes before reaching the end of the track, the game stops. The score is simply the number of pipes that the character has passed through.

With respect to the original game, we increased the distance between the couples of pipes, in order to give the patient enough time to perform the correct motion.

4.2.3 Ski game

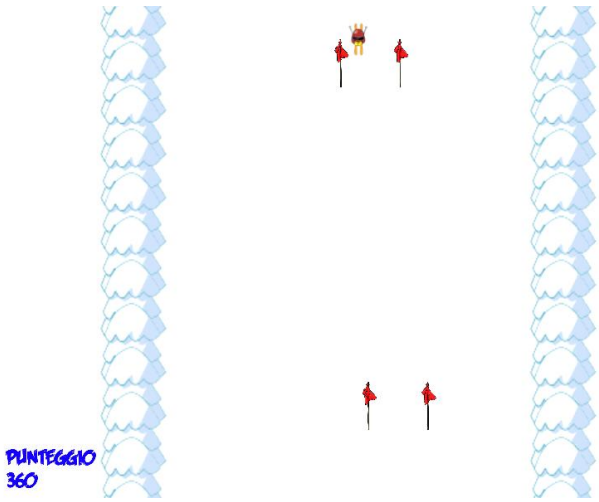

Figure 4.12 Ski game

This game involves both wrist extension/flexion and radial/ulnar deviation, although not in the same exercise. The setting is quite simple (Figure 4.12): a skier descending through a track. While descending he encounters couples of flags through which he has to pass. The player can move the character to the right and to the left using one hand. He/she can do this in two ways, depending on the mode selected: by radial and ulnar deviation, with the palm facing down, or by wrist extension and flexion, rotating the hand by 90° and making a movement like a slap. Like the Flappy Bird-like game, the wider the movement, the further the character moves on the screen. The relative position of the character with respect to the borders of the track is linked to the relative angle of the wrist with respect to the ranges of motion saved in the tuning session; in this way the player can reach both the borders of the track, avoiding

the frustration of missing the further flags due to limitations of the range of motion.

For each couple of flags that the player has passed through a certain amount of points is added to the score. No points are subtracted for not passing through a couple of flags. The game ends when the player reaches the end of the track. The score can be also an indirect feedback for the therapist regarding the patient's performance.

As anticipated, the track can be either random generated or created by the therapist. The random generation takes some parameters from the therapist, e.g. number of flags, distance between the flags, and then automatically creates the track. Custom generation requires the therapist to perform the exercise that he/she wants to be replicated. While performing the exercise, the application will track the excursions of the therapist's wrist and place the flags accordingly.

The game included another mode, where the player had to avoid the trees placed on the track. In order to do that, the player had to perform a quick movement either to the left or to the right with the hand. We decided to remove this mode because it was too difficult (Section 5.3).

4.2.4 Plane simulator

The last game is a plane simulator. It involves both wrist flexion/extension and radial/ulnar deviation in the same exercise. It can be played with both hands as well as with one hand. The hands can be both opened or closed to a fist.

The game is quite simple: the player has to pilot a plane through a series of rings. In order to do so he has to move one hand or both hands as if they were the plane itself. Bending up the wrist will tilt the plane upwards while bending the wrist down will result in the plane tilting downwards and following that direction. Same goes for bending the wrist to the left and to the right.

During the experimental sessions we observed that children tend to immerse in the game, forgetting to control their hands positions, so we added some visual help for both the two hand mode and the single hand mode.

In the two hands mode the main problem was that the children were often overlapping their hand, resulting in bad tracking for the *Leap Motion Controller* (LMC). We added two placeholders (the yellow hand shapes in Figure 4.13) for the hands that indicate the optimal distance between the hands. Two hands overlays (the green hand shapes in Figure 4.13) move accordingly to the player's hands and show the real distance between them. If the hands are not too close or too far apart, the overlays are colored green; otherwise they become red and a warning message appears on the screen. The arrow in Figure 4.13 shows to the player in which direction he/she has to move the plane in order to pass through the next obstacle.

In the single hand mode we observed that children were not aware of the LMC position while playing, so we added a LMC placeholder on the screen and a hand overlay that shows to the player the position of his/her hand relative to the LMC (Figure 4.14).

Figure 4.13 Plane simulator – two hands

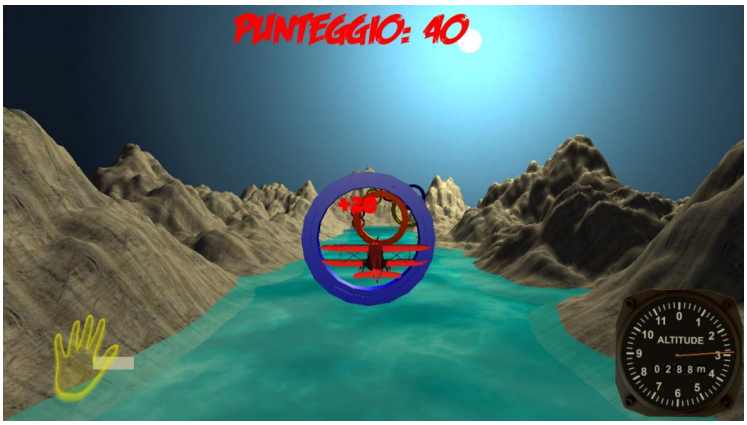

Figure 4.14 Plane simulator – one hand

The tracks are created by the therapist, in a similar way as the ski game. The therapist performs the exercise and the application tracks his/her movements and places the rings. Before creating the track, the therapist can customize some parameters such as the plane speed or the time interval between the placement of a ring and the next one. In this way the therapist can influence the speed of the exercise making it more or less difficult.

The scoring system is similar to the one implemented in the ski game. Each time the plane passes through a ring, the score is increased by a certain amount. Avoiding a ring does not decrease the score. The game ends when the player reaches the last ring.

Chapter 5

Testing and data analysis

In this chapter we present the set of experiments that we performed to validate the games on human subjects.

We performed three experimental sessions involving human subjects. The first two sessions were mainly used to tune the development of the games base on the subjects and therapists feedbacks. In the following sessions we focused more on collecting data in order to evaluate how the subjects used our games.

5.1 Experimental setup

Each experimental session took place at the Clinica Pediatrica G. e D. De Marchi. Each session was run on a notebook HP Pavilion dv6 with a 15.6" screen, Intel® Core™ i5-2410M CPU @2.30GHz, 4GB DDR3 SDRAM, Intel Sandy Bridge-MB GT2 video card, Windows 7 Home Premium 64 bit OS. The notebook was placed either on a desk or on a medical bed, based on the therapists' choice. The *Leap Motion Controller* (LMC) was placed between the notebook and the subject, on the same surface of the notebook, facing upward, about 12 cm away from the notebook.

In front of the notebook was placed a chair with a seat that would let the subjects extend their arms with the hands above the LMC, keeping a hand-LMC distance of at least 10 cm.

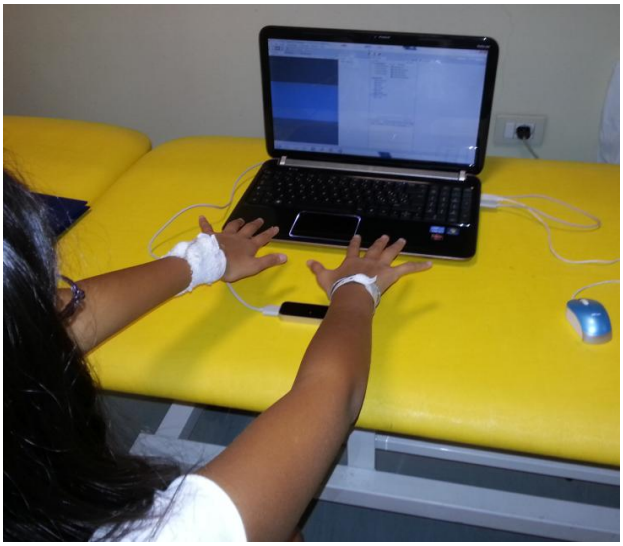

Figure 5.1 Experimental setup without the bolster

We tested four different configurations for the positioning of the arms. One had the subjects keeping their arms above the leap without any support (Figure 5.1).

Figure 5.2 Experimental setup with the bolster

The second configuration added a bolster under the forearm, as a support (Figure 5.2). The aim of these two settings is to have the subjects keeping their forearms as straight as possible, moving only the wrists in order to play. Furthermore, the second configuration helps reducing the effort of the subjects' shoulders. We opted for this setup because the bolster is frequently used in physical therapy, hence it is easy to find one in a dedicated ward.

The third configuration (Figure 5.3) added a couple resting orthoses - generally used for the fixation of the foot and ankle – on the bolster. Aim of the orthoses was to avoid the compensatory movement of the forearms performed by the subjects instead of bending the wrists. The choice of using the orthoses came from the therapists, since they generally use these supports in the clinic.

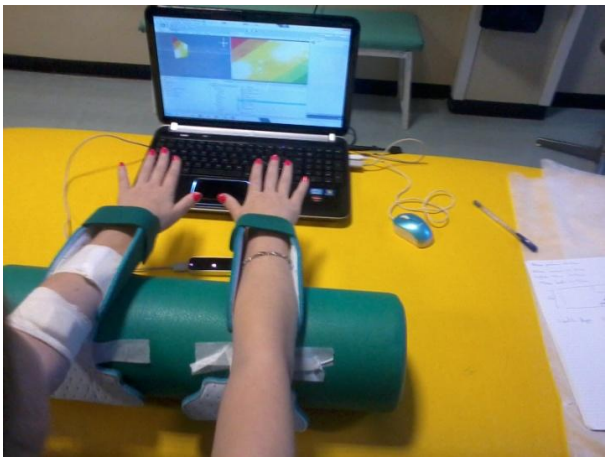

Figure 5.3 Experimental setup with the bolster and the orthoses

Finally, in the fourth configuration (Figure 5.4) we substituted the bolster with a higher wedge. We made this change because we noticed that using the bolster the subject's hand went too close to the LMC while performing the flexion movement. Also the therapists proposed to change the support, because they noticed the subject's tendency to tilt her forearms back and forth, hence the need of a wider surface to lay the arms.

Figure 5.4 Experimental setup with the wedge and the orthoses

5.2 First experimental session

Three subjects – all females – took part to the first experimental session. We will refer to the subjects as S1, S2, and S3. S1 was ten years old, S2 was fifteen years old and S3 was twenty-one years old. S2 and S3 had articular issues affecting their hands and wrists, while S1 had limitations to the ankle movements.

The aim of the first experimental session was to obtain a first feedback that would validate our design, both from a medical point of view and with respect to the subjects' entertainment. In order to reach this goal, we had the subjects perform several tests, for an overall duration of the session of about two hours. With S2 and S3 we focused on the hand exercises, while thanks to S1 we tested if the games could be played also using the feet.

In this set of experiments we tested two of the four games: the flight simulator and the Flappy Bird-like one. The flight simulator, in particular, was tested both with the hands and with the feet.

The tests were performed using the experimental setup defined in Section 5.1. In this session we used the version 1.2 of the Leap Motion SDK. We placed the notebook and the LMC on a desk, while the subjects sat on an adjustable stool.

The initial tests were performed without any support for the hands. The therapists noticed some fatigue in the subjects and we decided to put a bolster between their forearms and the desk, so they could lay their arms on it.

We asked the therapist to create a custom level for the flight simulator game, so she could simulate an exercise performed in a typical training session. Moreover, by doing this, we were able to show to the subjects how the game works and which movements they had to perform in order to complete the exercise. For the Flappy Bird-like game, instead, we used the random generator, creating a different level for each test.

5.2.1 Tested game modes

All the tests were conducted with the subjects only using their right hand. The therapists decided that they wanted to test only the one hand mode of the flight simulator game since they considered the two hands mode to be too difficult and wearing. The Flappy Bird-like game was tested both in the original mode and in the continuous movement mode.

5.2.2 Users' feedback

The feedback from the subjects was quite good; they all enjoyed the games and, in particular, the scoring system added a challenge factor among the subjects that led them to focus even more on each exercise.

The subjects also gave us some feedbacks regarding the look and feel of the games, suggesting some additions and changes that would have made the games more appealing. In particular, for the flight simulator, they asked us to add some background music in order to make it more lively, and to modify the positions and textures of some game objects in order to have a better view and understanding of what is going on in the game.

The therapists' feedbacks were also good. They noticed that the subjects enjoyed the exercises much more and it did not look like they were doing exercises. The subjects were doing without complaint the same exercises that they found to be boring and difficult during standard physical therapy. The level of focus required by the game, the victory goal and the level of entertainment created by the game itself and by the presence of the other subjects, exceeded the fatigue induced by performing the exercise. This may have been the most important feedback in order to evaluate the usefulness of our games and it allowed us to evaluate the goodness of our design choices.

An issue that we noticed while observing the tests of the flight simulator, was that the subjects tended to focus too much on the game and did not check their hand position relative to the LMC position, risking to go out of the LMC's field of view. This issue has been resolved at a later stage by adding to the in-

game graphic an overlay of the hand that shows its position with respect to the LMC (Section 4.2.4).

As mentioned before, we also made some tests using the feet instead of the hands. We wanted to verify if it was possible to trick the LMC into thinking that the subject was using her hand instead of her foot. If that was possible, the therapists could have used the games also for ankle rehabilitation. Sadly, the experiment did not go well. Being the LMC optimized for hand tracking, it had some issues recognizing the foot as a hand, making the flight simulator game unplayable.

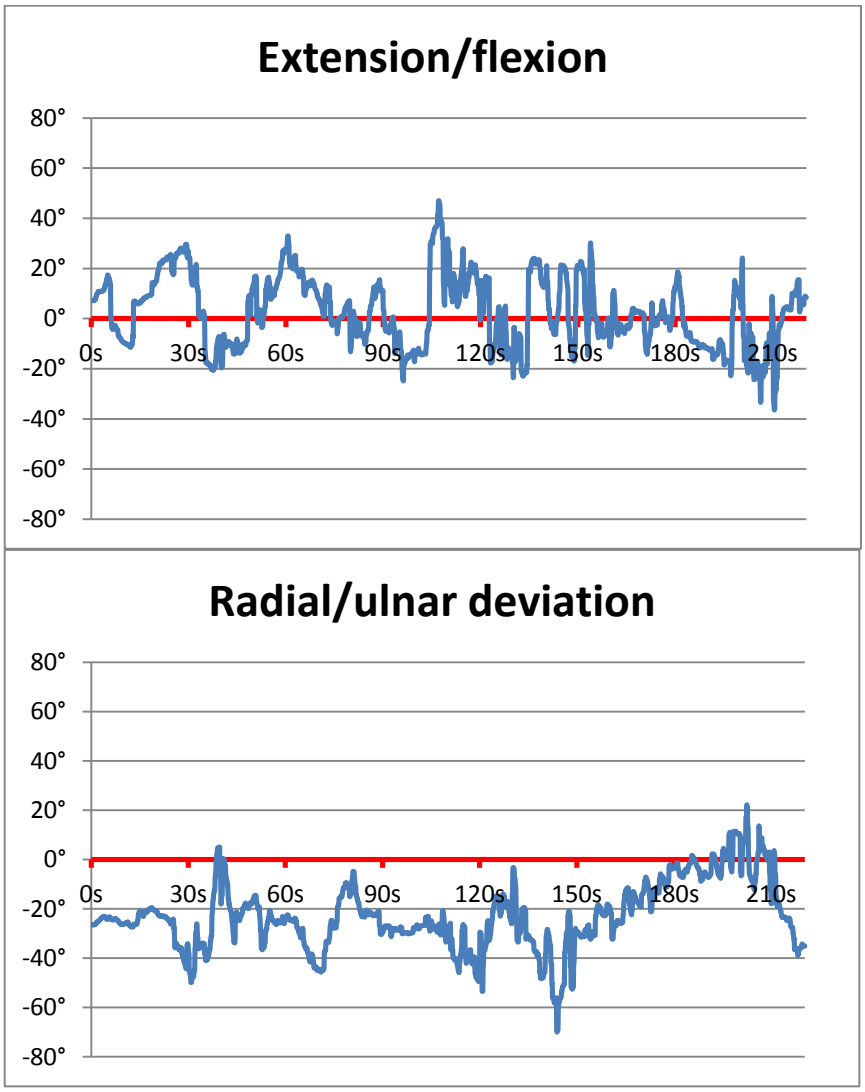

Figure 5.5 Performance of S2 playing to the flight simulator game

5.2.3 Data analysis

In this section we present the data that we retrieved during the experimental session. We focus only on the exercises performed with the hands, since the system proved to be not suitable for playing with the feet.

Figure 5.5 shows the data collected from S2 playing to the game using her right hand, without using the bolster as a support.

The positive values in the extension/flexion plots represent the extension of the wrist, while the negative values are associated to the flexion. In the radial/ulnar deviation plot, instead, positive values are associated to ulnar deviation, while the negative ones are associated to the radial deviation.

The first thing that we notice, looking at the plot, is that the deviation movement is imbalanced. Comparing with the performance of S3 playing the same game (Figure 5.6), we note that they have the same trend, but the deviation plot in Figure 5.6 is centered in the origin. This means that the offset in the plot of Figure 5.5 does not depend on the level generated by the therapist but is likely due to the position of the end at the beginning of the game. In fact, the plane simulator game has a preliminary phase where the application asks to the patient to keep his hand straight on the LMC for a small amount of time, in order to save the information about the wrist's angles at rest. This information is later used to adapt the movement of the plane to the movement of the hand. Hence, it is likely that S2 started the game with a radial deviation of almost 20°, setting the zero at that offset.

From a qualitative point of view we can see how the flexion and extension ranges in Figure 5.5 are quite balance, even though the extension has peaks a little bit higher than the flexion. We can also see from both the plots in Figure 5.5 how the therapist made a uniform level, that made the patient exercise both extension and flexion, and radial deviation and ulnar deviation.

As we can see, the plots are noisy; this depends on two factors: the LMC and the bolster. The LMC's tracking is a generally noisy, it could be seen quite immediately using the Leap Visualizer how the virtual counterparts of the

hand shake a bit while tracking. Not using the bolster as a support also influenced the performance, since it was wearing for S2 to keep her arms lifted. The effect of the bolster on the performance can be seen by comparing the plots in Figure 5.6 and 5.7. Both figures illustrate the performance of S3 playing the flight simulator game with her right hand. But the test in Figure 5.6 was performed without the bolster, while in the test illustrated in Figure 5.7 S3 was able to lay her forearm on it. We can see that while the plots in the two figures have the same trends, those in Figure 5.7 are crispier than those in Figure 5.8. This proved how useful can be having a support where the subjects can lay their forearm while doing the exercise. Reducing the fatigue, the patient can indeed perform a cleaner exercise.

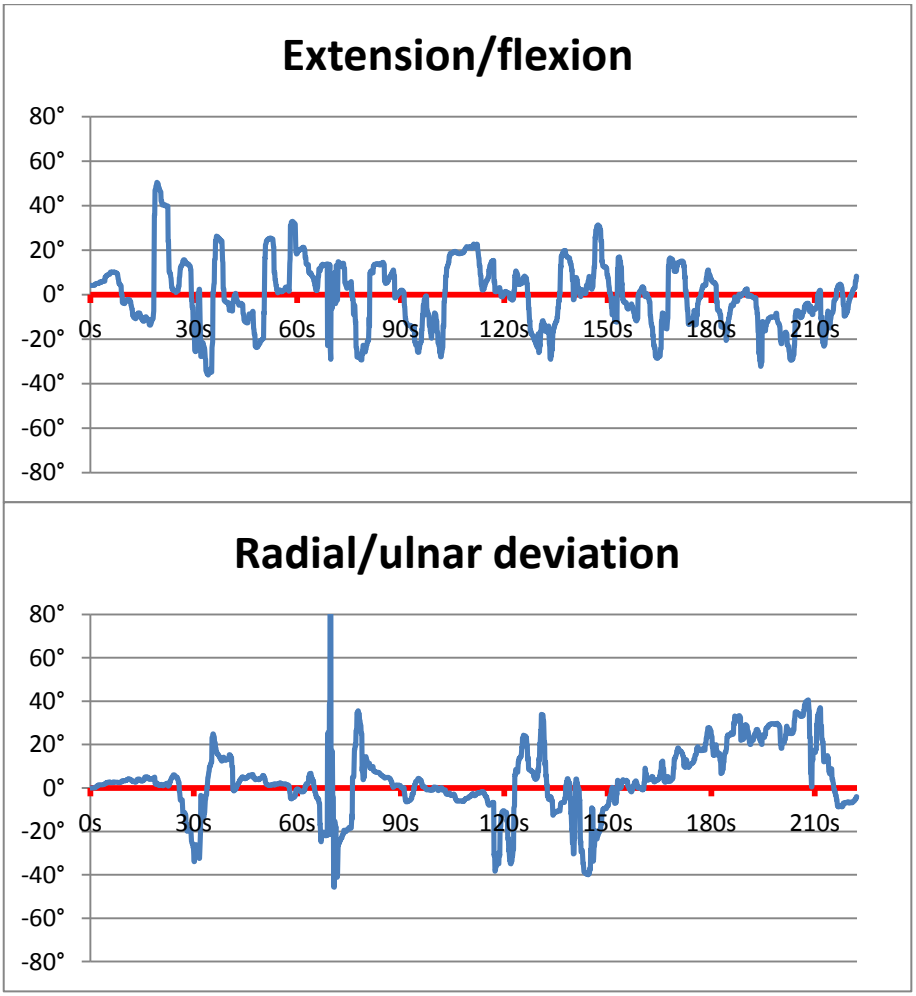

Figure 5.6 Performance of S3 playing to the flight simulator game without the bolster

In the radial/ulnar deviation plot of Figure 5.6 we notice a peak that exceeds 80°. This is due to a disturbance that went in the field of view of the LMC, temporarily affecting its tracking. Especially using the version 1.2 of the Leap SDK, we noticed these strange behaviors when an external object or part of a body entered the LMC's field of view while someone was playing. Hence, the need for the therapists and the other who participate to the therapy, to leave a bit of space between them and the patient who is doing the exercise. It is important also to clear the LMC's flied of view from external objects that could interfere with the tracking.

As said before, analyzing the plots in Figure 5.5, 5.6 and 5.7 we note how the therapist created a uniform exercise that stimulates the wrist joint in all the four main directions. Especially with respect to the extension/flexion movement S3 gradually alternated flexion and extension, keeping the range under ±40°. The deviation side of the exercise was less balanced. As we see, in the first part ulnar and radial deviation alternate, but radial deviations are wider than the ulnar ones. In the end there is only an increasing ulnar deviation. This remarks the need for a random generator that creates levels more uniform as possible.

Figure 5.8 illustrates the performance of S2 playing to the original mode of the Flappy Bird-like game. She played the game with her right hand, resting her forearm on the bolster. We note that she made a lot of sharp movements in the first five seconds, but as she get used to the game, the peaks get more distant.

Anyway, this game mode requires an impulsive movement rather than a uniform one. This could be a problem, because could cause pain in some patients or can stress too much the joint. If we look again at the peaks in the beginning of the plot in Figure 5.8 we can see how S2 performs six sharp extensions in about five seconds. Luckily she did not complain about pain, but the joint was too much stressed.

Figure 5.9 shows the performance of S3 playing to the original mode of the Flappy Bird-like game. She played with her right hand and used the bolster to rest her forearm.

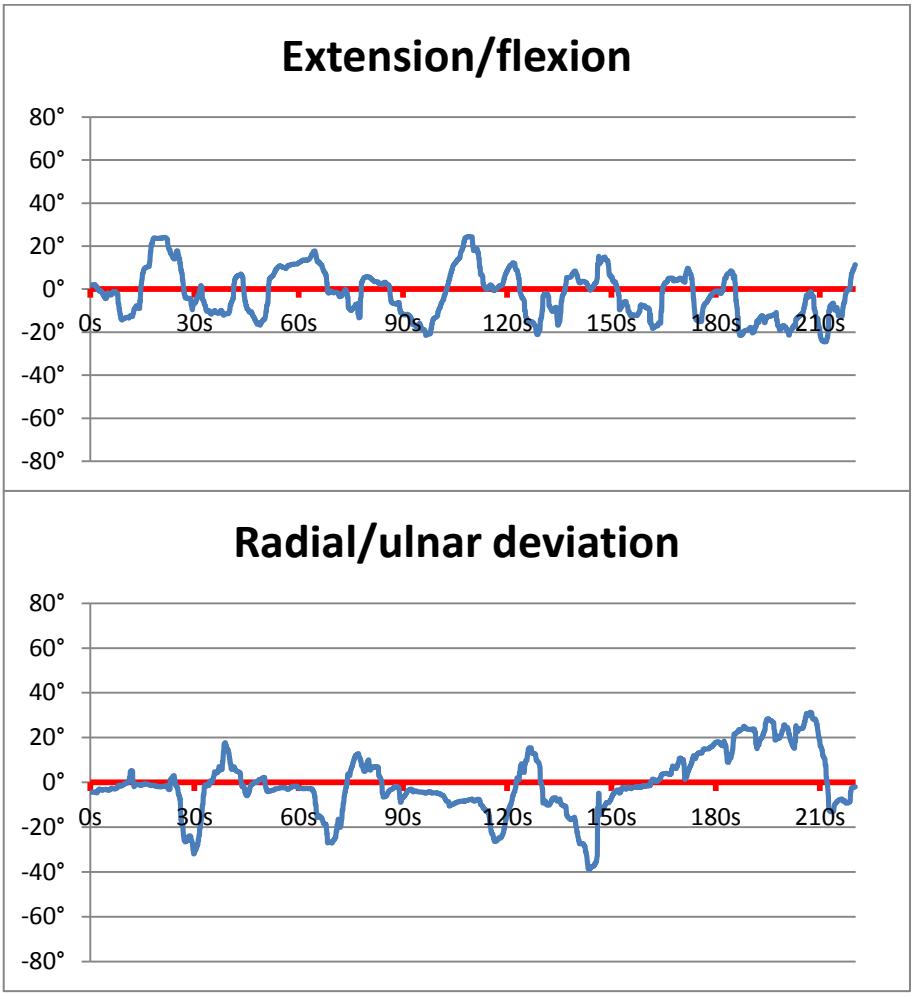

Figure 5.7 Performance of S3 playing to the flight simulator game with the bolster

We can see how S3 had a more relaxed approach. Even though the plot still presents some sharp peaks, as the one of Figure 5.8, they are more distant from one to the other. Also in this case the exercise is not uniform. There is no gradual movement and we can see how hard it is for the subject to reach more than 20° in extension with a single impulse movement.

These evaluations led us to not consider this game mode as a good exercise. Anyway we decided to keep it with the other games, since the subjects had fun playing to it.

Figure 5.10 and 5.11 illustrate the performances of S2 and S3, respectively, while playing the continuous movement mode of the FlappyBird-like game. The first thing that we notice, looking at the plots, is that the movement is not balanced between flexion and extension. In five plots out of six, the extension

movement is required more than the flexion movement. It depends on the game random generator, which created levels with targets not evenly distributed.

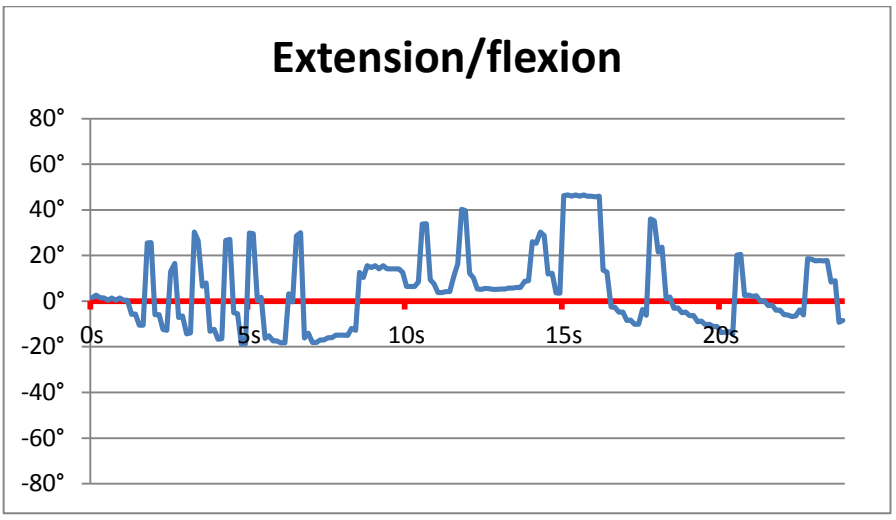

Figure 5.8 Performance of S2 playing to the original mode of the Flappy Bird-like game

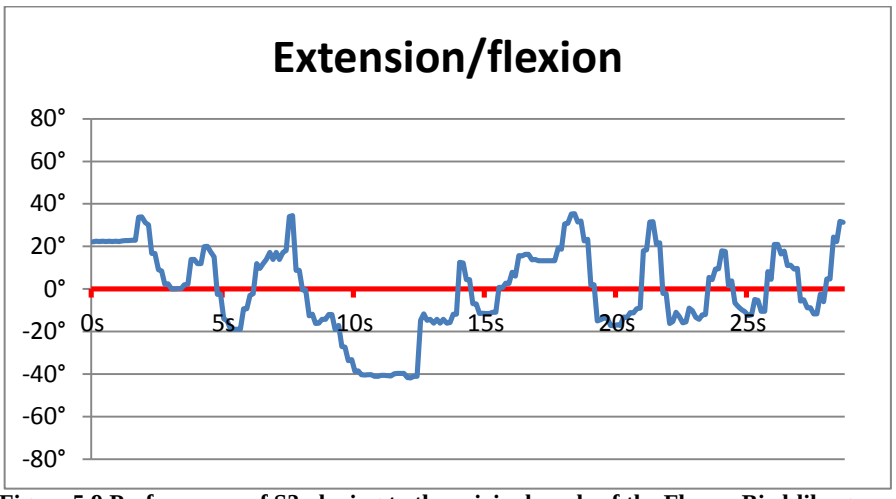

Figure 5.9 Performance of S3 playing to the original mode of the Flappy Bird-like game

Analyzing the plots in Figure 5.10 we can see how the overall movements of S2 change gradually, especially in the third test, since she understood how to move properly the character and had more training. Also the sequence of plots in Figure 5.11 shows how S3 gradually got acquainted with the game and performed better after some practice. In particular we can see how in the first test she lose almost immediately. In the second test she lasted longer, but still she had some problem stabilizing the movement, see for example the peaks between fifteen and twenty seconds that slowly decrease in intensity. In the

last test, probably due also to an easier level created by the random generator, she performed a quite uniform exercise, with gradual movements, though the angles where not so wide.

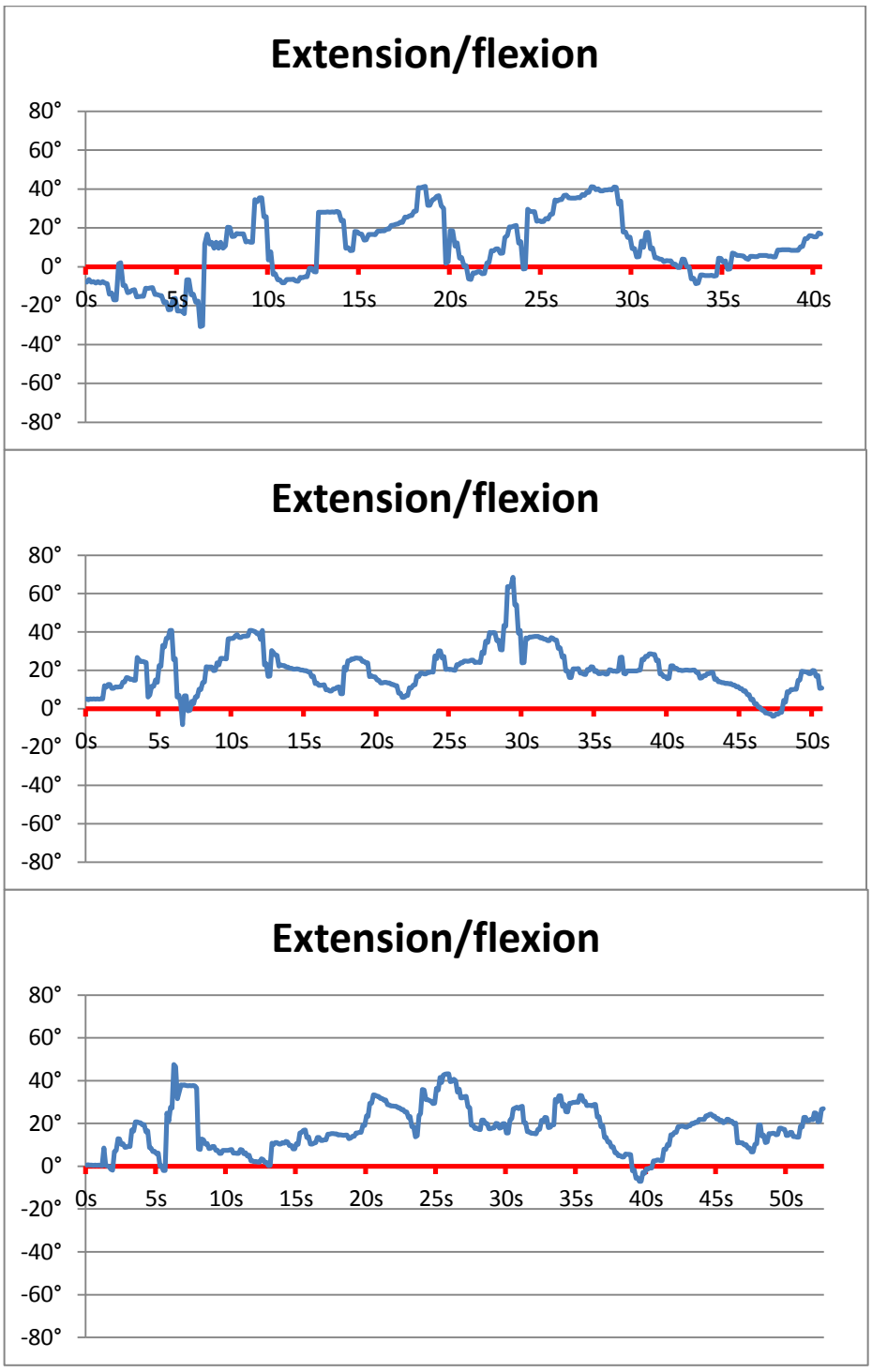

Figure 5.10 Performances of S2 playing the continuous movement mode of the Flappy Bird-like game

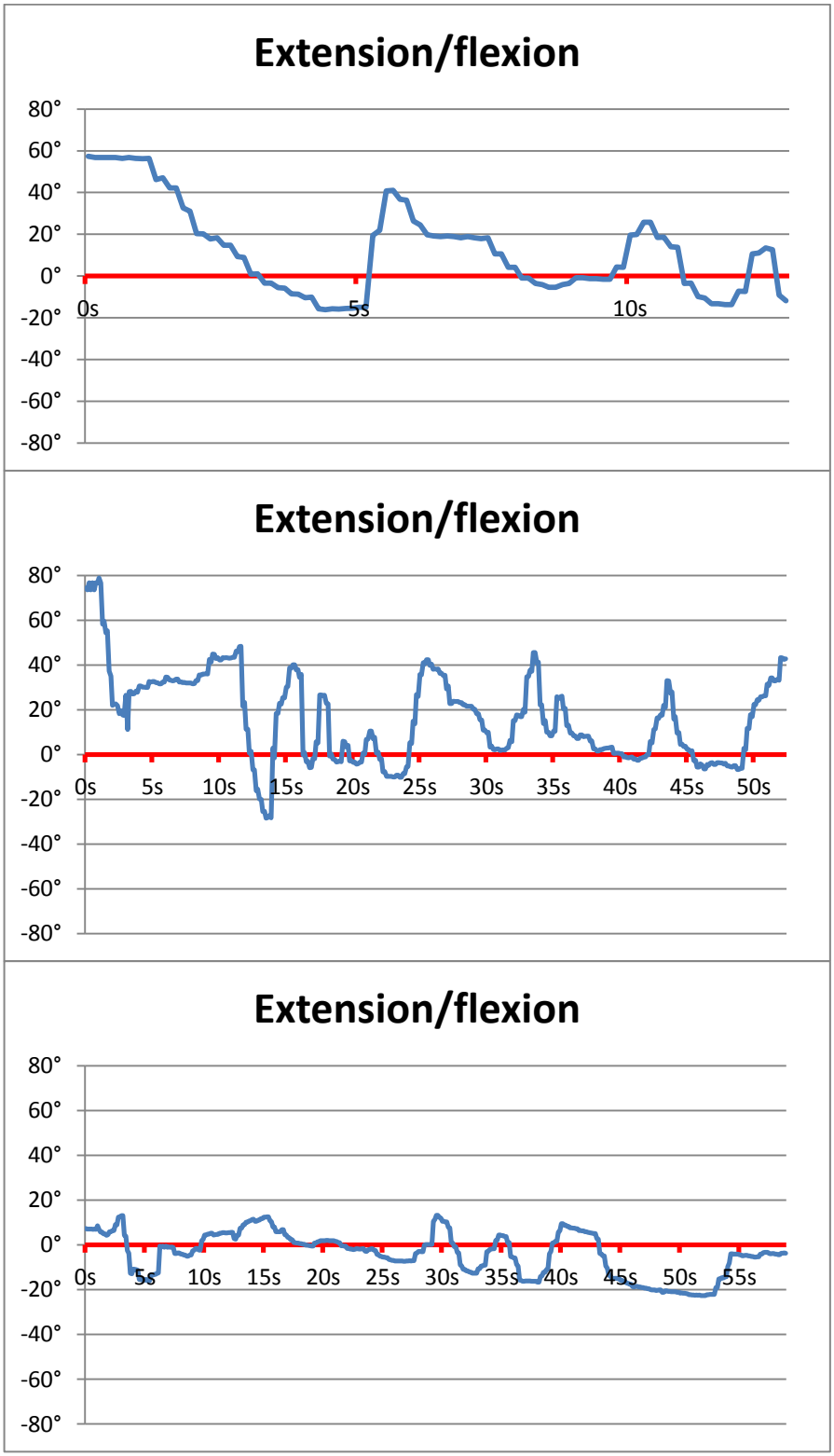

Figure 5.11 Performances of S3 playing the continuous movement mode of the Flappy Bird-like game

5.2.4 Final remarks

This first experimental session helped us to validate our design choices. We could see how the subjects were effectively entertained by the games. We have seen, in particular, how playing these games in group can increase the fun, encouraging the patients to exercise. Also the positive feedback of the therapists helped us to evaluate the goodness of what we designed, confirming the usefulness of these games.

The session also gave us some useful indications about how to change and improve our games. The two hands mode in the flight simulator and the original mode in the Flappy Bird-like game are not suited for all the patients. The two hands mode is too difficult for someone and require more concentration than the one hand mode. While, the original Flappy Bird mode requires too sharp movements that not everybody is capable of doing. Furthermore, the original mode make the patients perform a less uniform movement than the one performed in the continuous mode. We decided to leave those two modes in the relative game, anyway, if some patients want to try a different gameplay experience.

The feedbacks about the visual aspects were useful as well, helping us improving the gaming experience and making the games more appealing for the users.

5.3 Second experimental session

Two subjects, S1 and S2, took part to the second experimental session. They were both female: S1 were twenty years old, while S2 was the same S2 that participated to the first experimental session. Both S1 and S2 had movement limitations affecting the hand and wrist joints.

In this second experimental session we tested the remaining two game: the rhythm game and the ski game. We also presented the changes and additions made to the flight simulator game, including the replay mode. We performed several tests and retrieved the data from each performance. The results of the analysis of those data are discussed in Section 5.3.4. Since we had less

subjects, the experimental session lasted less than the previous one: about one hour and a half.

The tests of this experimental session were performed using the general setup described in Section 5.1.

For this session we used the version 2.0.4 of the Leap Motion SDK, which made the hand tracking more precise and robust. The motion management, gesture recognition and data acquisition aspects of the game were then changed according to the new SDK.

We put the notebook and the LMC on a medical bed, while the subjects sat on a bench. We adjusted the height of the bed in order to respect the distances defined in Section 5.1. For every test made during this session, the subjects used the bolster as a support for their forearms.

In this session we asked again to the therapist to create a custom level for the flight simulation game. While for the ski game we opted for the random generator. The levels of the rhythm game were pre-set, so no decision was made there.

5.3.1 Tested game modes

We tested both the single hand mode and the two hands mode of the flight simulation game. We did so in order to collect data about both the game modes and to show to the therapists how the replay mode works. We tested both the continuous movement mode – the one where player has to make the character go through the flags - and the jerk mode – the one where player has to avoid the trees that come across the track – of the ski game. Unfortunately, this game was tested only by S2, because S1 had to leave early.

5.3.2 Users' feedback

Also in this session we received positive feedbacks from the subjects as they liked the new games that we presented. The only negative feedback was about the jerk mode of the ski game. S2 found it hard to play and said that the game mode was not so intuitive. We, together with the therapists, also noticed this

issue by watching her playing the game. We were asked to reduce the difficulty of both the rhythm game and the ski game, since the subjects had problems in performing well throughout those games.

The therapists were satisfied by the replay mode. They really appreciated the chance to see again the performed exercise, affirming the usefulness of this feature in evaluating the exercises performed at home by the patients. They also gave us some suggestions about some changes to apply to the ski game, like widening the gap between the flags, so that is more easy to pass through them, and widening the track in order to perform a more fluid exercise.

The therapists also pointed out a problem in the performance of the subjects. They noticed how the use of the bolster alone did not prevent the subject from performing compensation movements, tilting their forearms instead of bending their wrists.

5.3.3 Data analysis

The first tests that we analyze are those relative to the rhythm game. Figure 5.12 and 5.13 show the performances of S1 and S2, respectively.

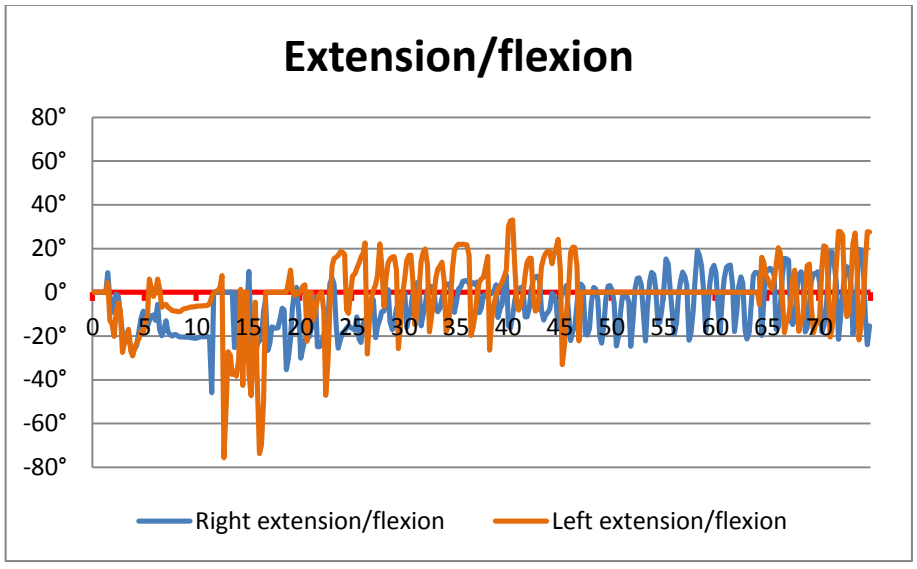

Figure 5.12 Performance of S1 playing to the rhythm game

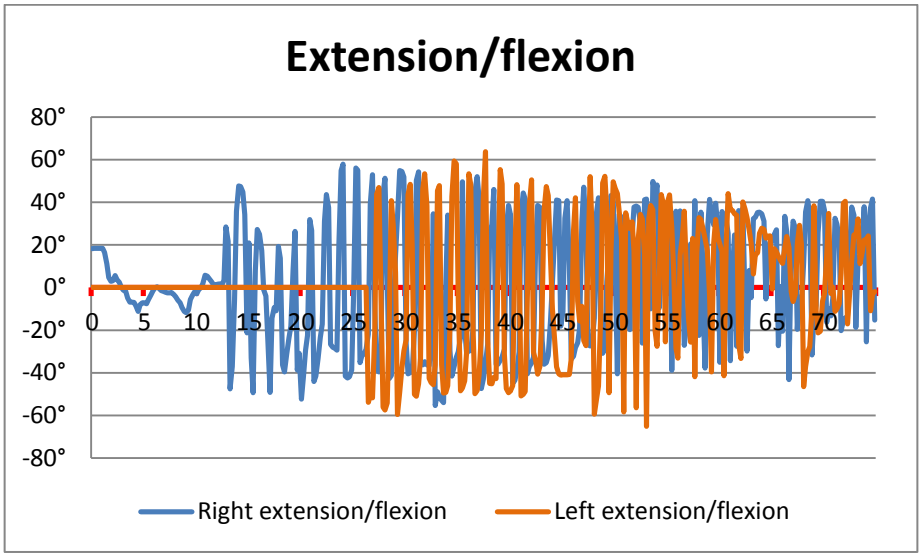

Figure 5.13 Performance of S2 playing to the rhythm game

We asked the subjects to play a level created by us on the song "Boulevard of broken dreams". They played with both hands, using the bolster as a support. We see from both the plots in Figure 5.12 and 5.13 that this kind of game does not provide a slow, gradual movement. Furthermore, the level that we created was too difficult for the subjects, requiring them to perform several sharp movements in a small amount of time, as we can see from the density of peaks in the plots. The flat parts of the plots are due to the LMC tracking system not being able to identify the respective hand in that period of time.

We made some tests both with the single hand mode and with the two hand mode of the flight simulator in order to see how the increasing difficulty of coordinating two hands instead of one affected the final performance.

Figure 5.14, 5.15, 5.16 and 5.17 show the plots relative to the performances of S2. The tests were performed using a custom level created by one of the therapists. S2 played twice with one hand (Figure 5.14 and 5.15) and twice again using two hands (Figure 5.16 and 5.17). Each time she used the bolster to rest her forearms.

As in Section 5.2.4 the positive values in the extension/flexion plots are associated to the extension movement, while the negative values are associated to the flexion movement. In the radial/ulnar deviation plots we alternate the meaning of the values for the right and the left hand, in order to show more

clearly when the hands were moving in the same direction. In particular, with respect to the right hand movement, the positive values are associated to the ulnar deviation, while the negative ones are associated to the radial deviation. Instead, for the left hand positive values are associated to the radial deviation and negative values are associated to the ulnar deviation.

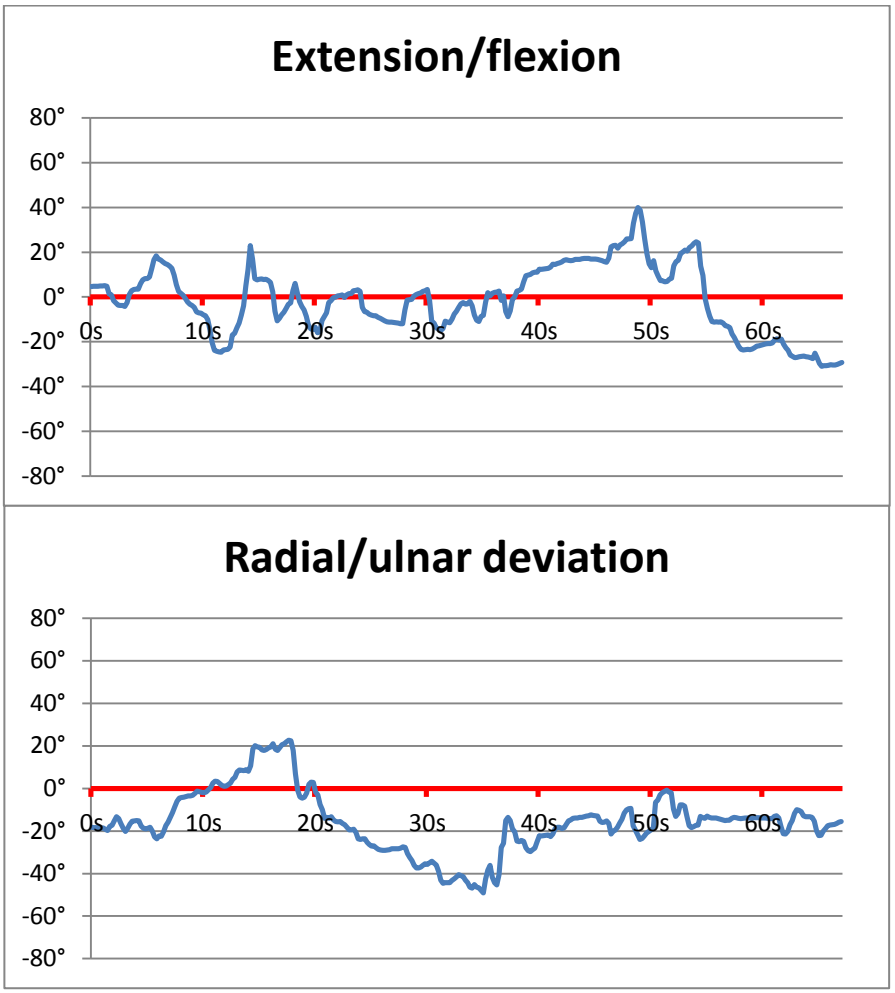

Figure 5.14 First performance of S2 playing to the one hand mode of the flight simulator game

The plots in Figure 5.16 and 5.17 show some imprecision in tracking. The flat parts of the plots are due, as for the rhythm game, to the LMC not identifying the hand. While the noise resulting in sudden peaks could be a consequence of the tendency of the subject to overlap her hands, making it hard for the LMC to perform a clear tracking. Despite this imprecision in tracking, we can see how the plots relative to the two hands mode have the same trends as those

relative to the one hand mode. Furthermore we can see how the left and the right hand moved accordingly while playing the two hand mode, hence the possibility of using this mode as well as the single hand one depends on the ability of the patient to coordinate both hands simultaneously.

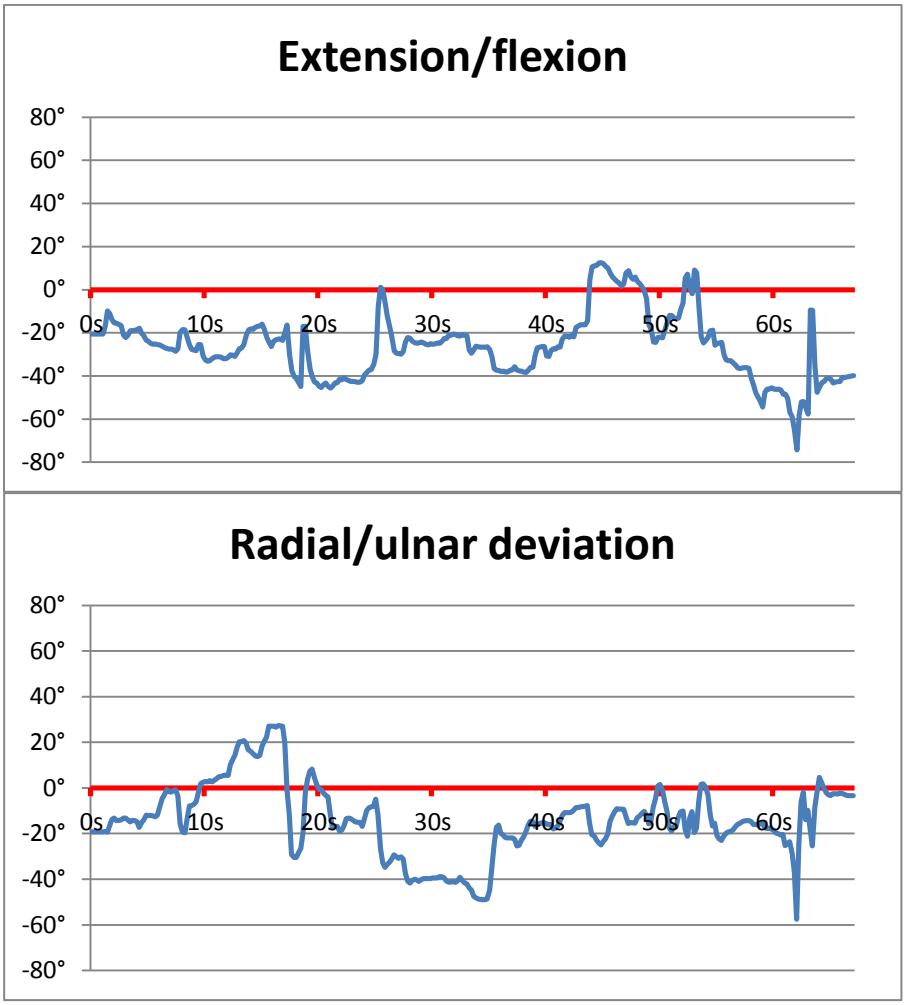

Figure 5.15 Second performance of S2 playing to the one hand mode of the flight simulator game

Figure 5.18 and 5.19 show the results of the tests done by S2 with the flight simulator game. Since she had to leave before the end of the session, we let her play a smaller level, just to show her how the flight simulator works in view of the next experimental session.

She played both the one hand mode (Figure 5.18) and the two hand mode (Figure 5.19). The experimental setup with bolster was used also for this tests.

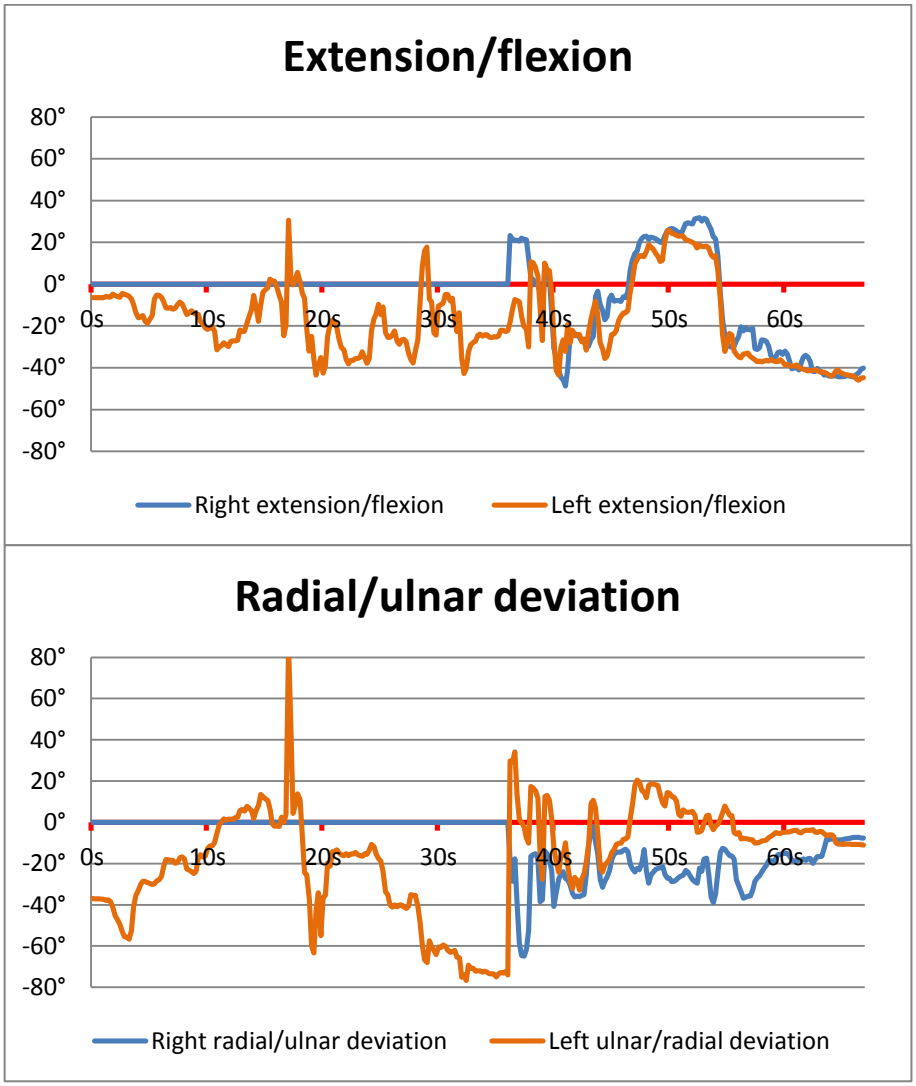

Figure 5.16 First performance of S2 playing to the two hand mode of the flight simulator game

Figure 5.18 does not give us much information about the one hand mode performance. We can see how the movements and transitions were quite smooth, meaning a correct execution of the exercise. Unfortunately the level used for the test was too short (and maybe too simple) to have a more substantial feedback.

Looking at Figure 5.19, instead, we can see how the deviation movement of the two hands was not coordinated as the extension/flexion movement. In particular, comparing the plot with that in Figure 5.17, we can see how the left hand lost track of the movement between ten and fifteen seconds. After the left

hand got back on track, was the turn of the right hand to lose track. As said for the one hand mode, the level was too small to have a complete feedback, but Figure 5.19 pointed out some issues in coordinating both hands simultaneously in order to play the game.

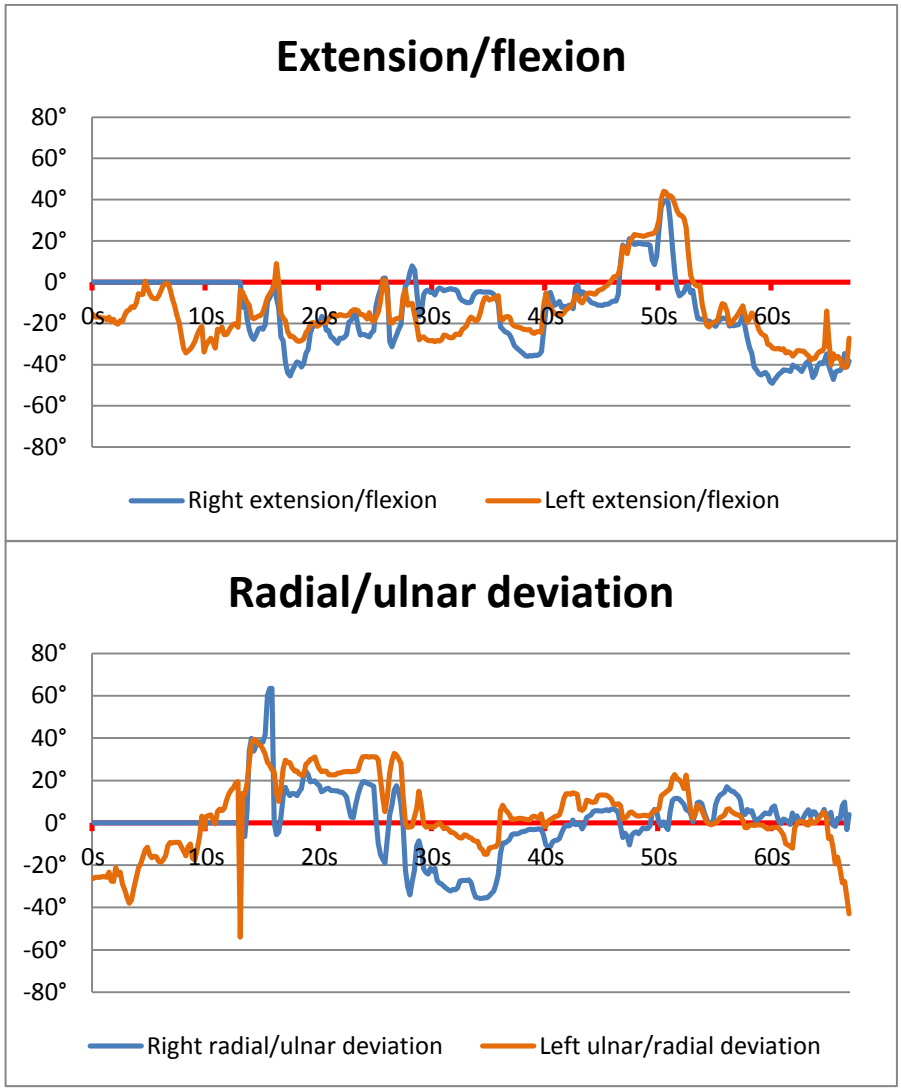

Figure 5.17 Second performance of S2 playing to the two hand mode of the flight simulator game

Finally, we analyze the tests relative to the ski game. As said before, only S2 played to the ski game. She tested both the palm facing down mode (deviation mode) and the palm perpendicular to the LMC mode (extension/flexion mode). She performed all of the tests using her right hand, with the forearm resting on the bolster. For each test we generated a random level. We analyze

only the data relative to the continuous movement mode (the one where the character has to pass through the flags) since the jerk mode (the one where the character has to avoid the trees) was found too hard to play.

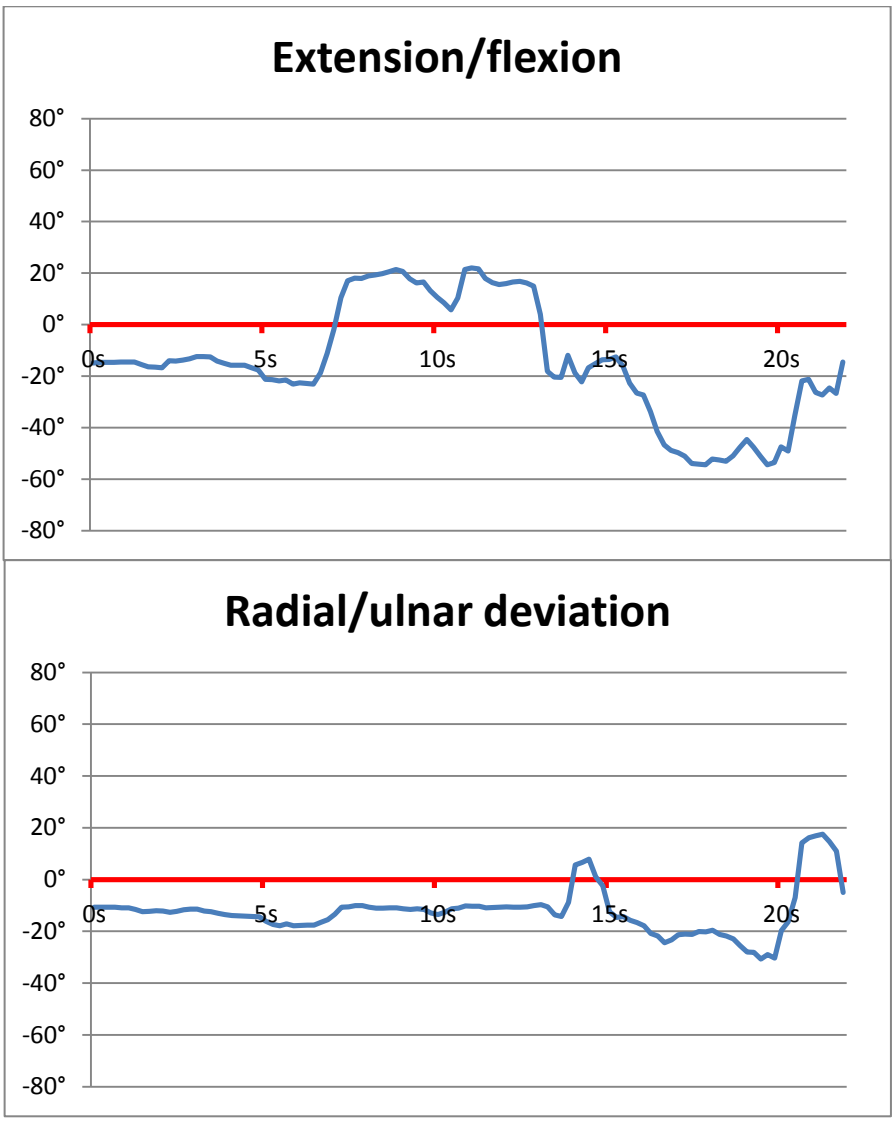

Figure 5.18 Performance of S1 playing to the one hand mode of the flight simulator game

Figure 5.20 shows S2's extension and flexion movements while playing to the extension/flexion mode of the game. We notice that the random generated level allowed the player to perform well-alternated movements. Watching live both the performances relative to the flexion/extension mode and to the deviation mode (Figure 5.21) we noticed that the speed of the game was too high, and sometimes S2 had problems reaching a couple of flags when the previous couple was near the opposite border of the track.

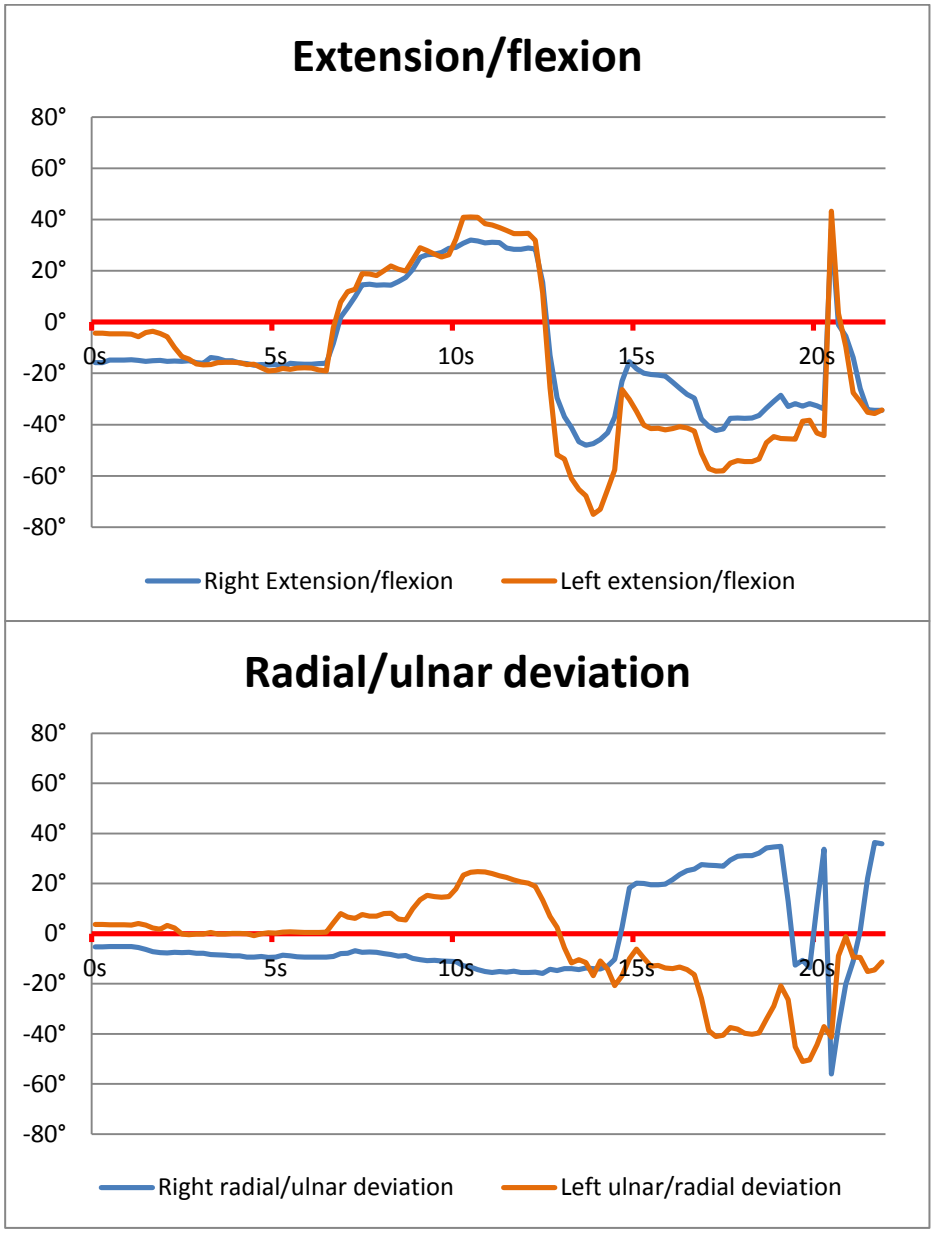

Figure 5.19 Performance of S1 playing to the two hand mode of the flight simulator game

Looking at the plot we can see how the movement required by the exercise was not smooth, due to the fast pace of the game. On the positive note, it allowed the subject to reach a wide range of movement, even though those values may be influenced by the tendency of the subject to compensate the wrist movement by tilting the forearm.

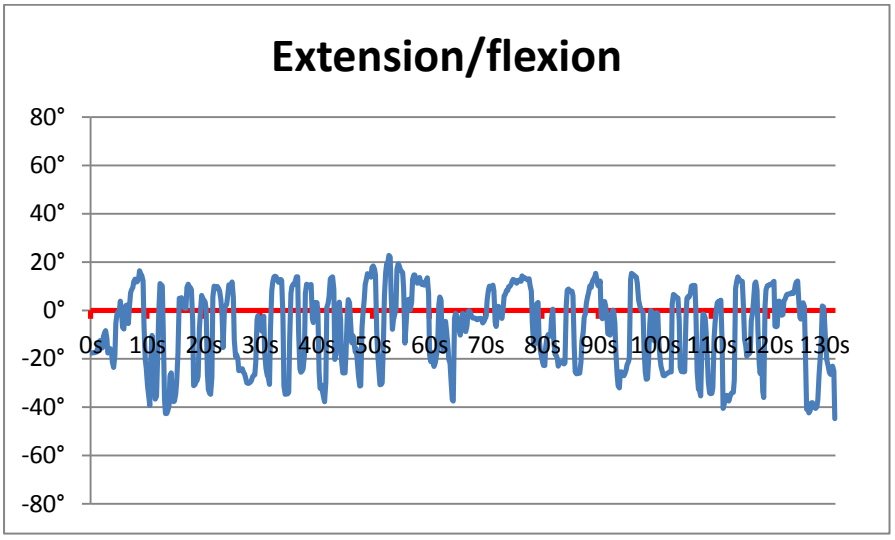

Figure 5.20 Performance of S2 playing to the extension/flexion mode of the ski game

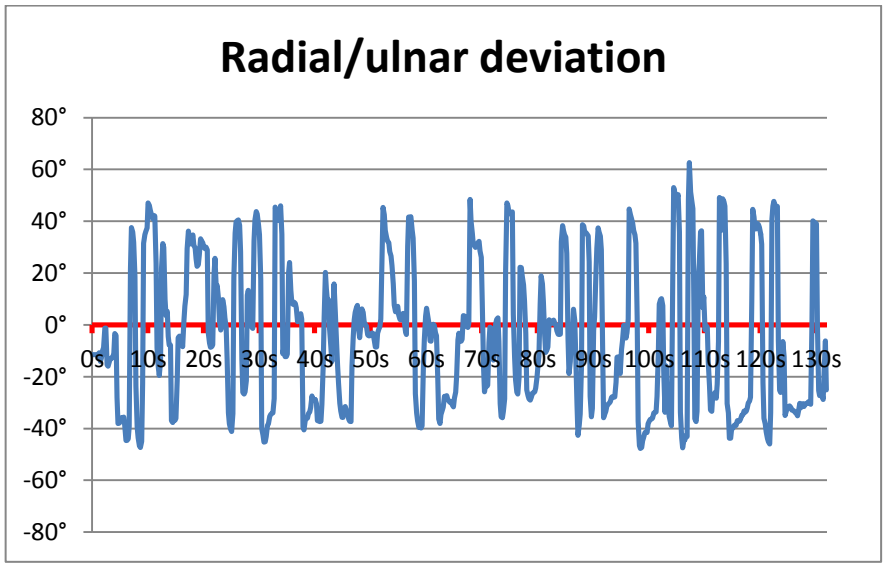

Figure 5.21 Performance of S2 playing to the deviation mode of the ski game

5.3.5 Final Remarks

Also in this case, our design choices were appreciated and were found to be useful. The only exception was the jerk mode of the ski game, which proved to be too hard. Since our design rules include the need for a game to be intuitive, we decided to remove the jerk mode from the game. The feedbacks also helped us in tuning the difficulty of the games, especially the rhythm game and the ski game. Moreover we were able to see how the two hand mode of the flight simulator game could be an efficient alternative to the single hand mode,

for the patients who can coordinate simultaneously the movements of both hands.

The replay mode was a huge success. The therapists were excited by the possibilities that this feature would give in terms of monitoring how the patient does his/her exercises when he/she is not assisted. Given the positive feedback that confirmed our initial choice, we decided to definitively adopt the replay mode in each game as a qualitative feedback of the patient's performance.

5.4 Third experimental session

The subject S1 that took part to the second experimental session was the only subject for the third session. We asked her to play every game in order to analyze her performance in both the games that she already played and the ones that she hadn't seen. Furthermore, she tested all the game modes of each game. The session lasted about half an hour.

The tests of this experimental session were performed using the general setup described in Section 5.1.

In this session we used the version 2.1.0 of the Leap Motion SDK, which improved the hand tracking precision.

We put the notebook and the LMC on the same medical bed used in the second session. The subjects sat on the same bench, as well. We adjusted the height of the bed in order to respect the distances defined in Section 5.1. For this session we used the configuration with the bolster and the orthoses.

In this session we used the flight simulator level created by the therapist in the previous session. We still used random generated levels for the Flappy Bird-like game and for the ski one. Finally, we used a pre-set level for the rhythm game, different from that used in the previous session.

5.4.1 Tested game modes

As said before, we tested all the four designed games. S1 played twice to the rhythm game and to the continuous mode of the Flappy Bird-like one. She

then played twice the one hand mode of the flight simulator and once the one hand mode. Unfortunately, we were able to test only once the two modes of the ski game.

5.4.2 Users' feedback

Between the previous session and this one there were no substantial changes in the implementation of the games, hence both the therapists and the subject did not give us any particular feedback. The only feedback that we received was from the subject. Unlike what the therapists told us about the difficulty of the two hands game mode of the flight simulator, S1 told us that she liked that game mode more than the one hand one.

5.4.3 Data analysis

The first game that we tested was the Flappy Bird-like one. We focused only on the continuous mode, since – as we said in Section 5.4 – the original mode required to perform too frequent sharp movements. Figure 5.22 shows the plots of the two performances.

Although it was the first time that she played the Flappy Bird-like game, S1 was able to make it through almost half of the level, passing through nine couple of pipes out of twenty. In the second run, maybe because she was getting used to the movements, she improved her score by four, passing through thirteen couples of pipes. We notice from the first plot in Figure 5.22 that the level random generator sometimes creates levels not well balanced between the two movements. From both the plots, especially from the second one, we see that the distance between the obstacles in the level allows the subject to perform gradual transitions from the flexion movement to the extension movement and vice versa. This results in a good execution of the exercise from the subject.

Figure 5.23 shows the plots relative to S1 playing the rhythm game. Following the feedbacks received in the second experimental session, we created a simpler level with less buttons. We also increased the distance between two buttons coming down on the same line. The effect of the increased distance

can be noticed comparing the plots in Figure 5.23 with that in Figure 5.13 showing the previous performance of S1. Indeed the density of peaks is decreased.

Even though we reduced the overall game difficulty, it was still hard for her to play the game. She scored 680 out of 1320 in the first run and 420 out of 1320 in the second, pushing, respectively, thirty-four and twenty-one out of sixty-six buttons. To be thorough, the score of the second run was influenced by the LMC having problems identifying the right hand, as shown by the second plot in Figure 5.24.

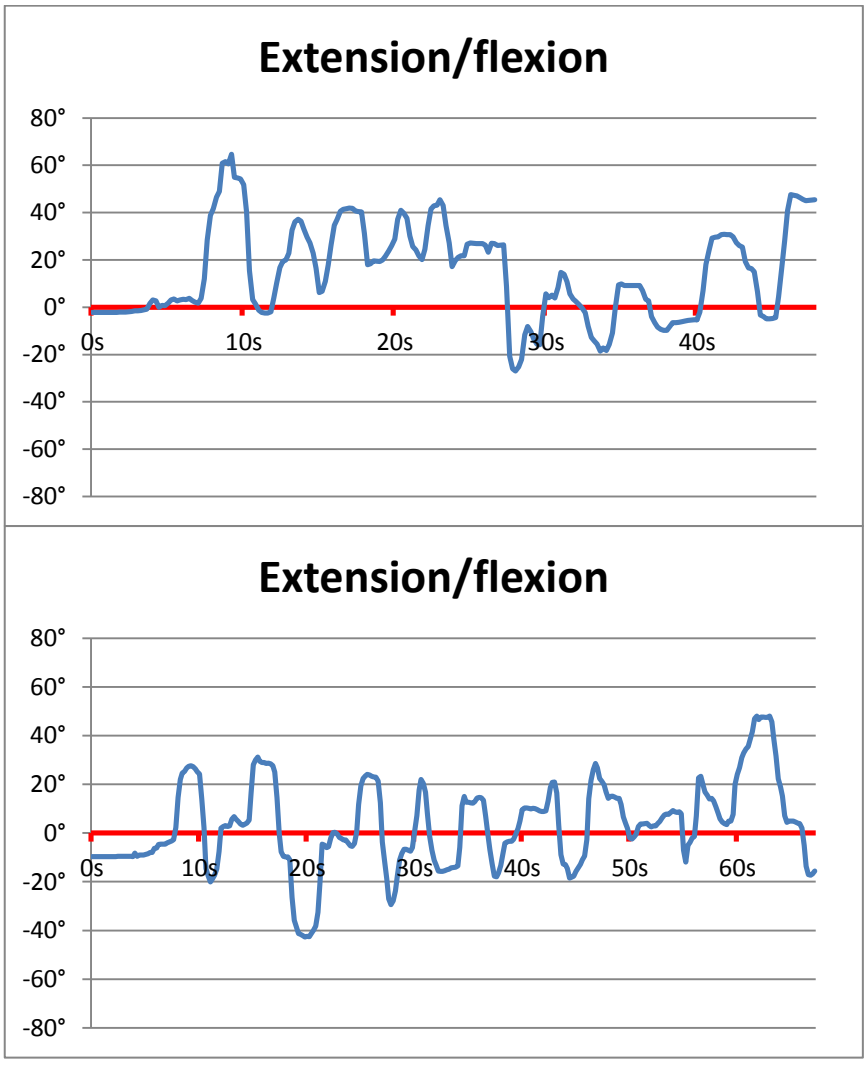

Figure 5.22 Performances of S1 playing to the continuous mode of the Flappy Bird-like game

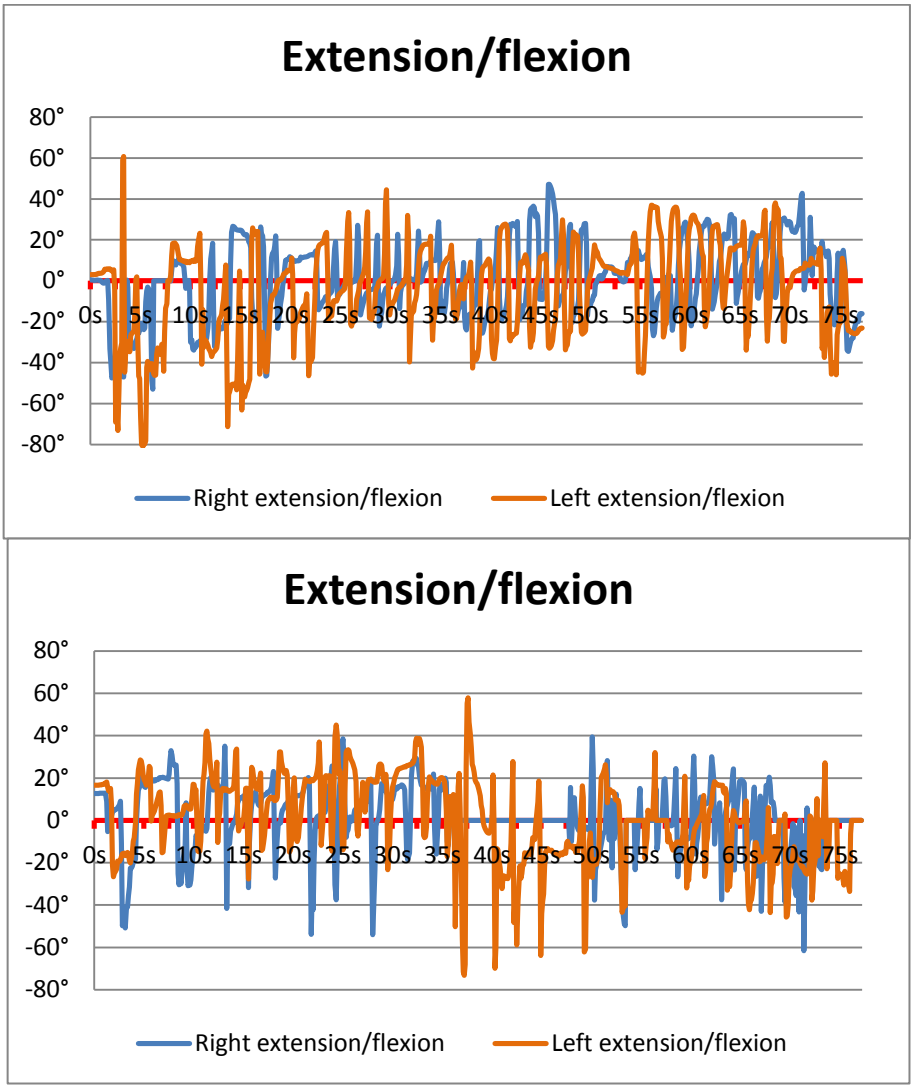

Figure 5.23 Performances of S1 playing to the rhythm game

We notice also that, even though the game is intended only for the flexion movement, it involves also the extension movement. The same thing happened in the previous session (Figure 5.13). This is probably due either to the subject not stopping his movement when she moves the hand back to the horizontal position or to a sort of run-up movement performed before virtually pushing the button, as she is trying to push a real button.

After the rhythm game we tested the flight simulator. We started with the two hands mode. We notice from Figure 5.24 that the movements of S1's hands were well-coordinated, except for some brief periods of time. Both this result and her score back up the feedback that she gave to us about how she preferred

the two hands mode, showing how this game mode is not hard for everyone. In fact she passed through all of the twenty-two targets, scoring 440 out of 440.

S1 obtained high scores also in the one hand mode (Figure 5.25 and 5.26). She obtained 440 points in the first run and 420 points in the second, having missed one target. This results show how she almost immediately got acquainted with the game's gameplay, obtaining the highest scores. The fact that she passed through all the targets in the first two runs also gives us a raw feedback on how well she performed the exercise, since she followed the movements set by the therapist. This is shown also by the similarity in the trends of the plots in Figure 5.24 and 5.25.

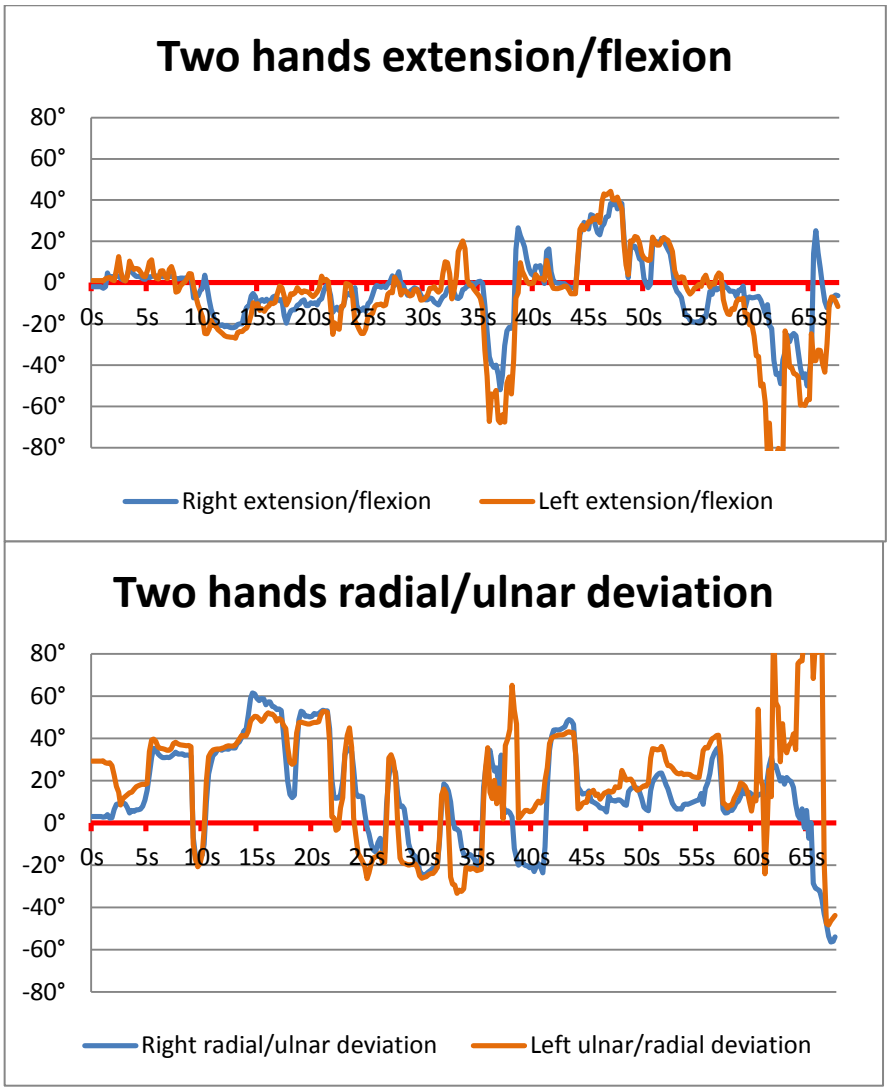

Figure 5.24 Performance of S1 playing to the two hands mode of the flight simulator

The plots of Figure 5.26 show that she had some issues controlling the plane in the third run. Since she performed well in the previous two, this is due probably to noise in the LMC's tracking, resulting in a strange behavior of the plane that she tried to balance with her hands.

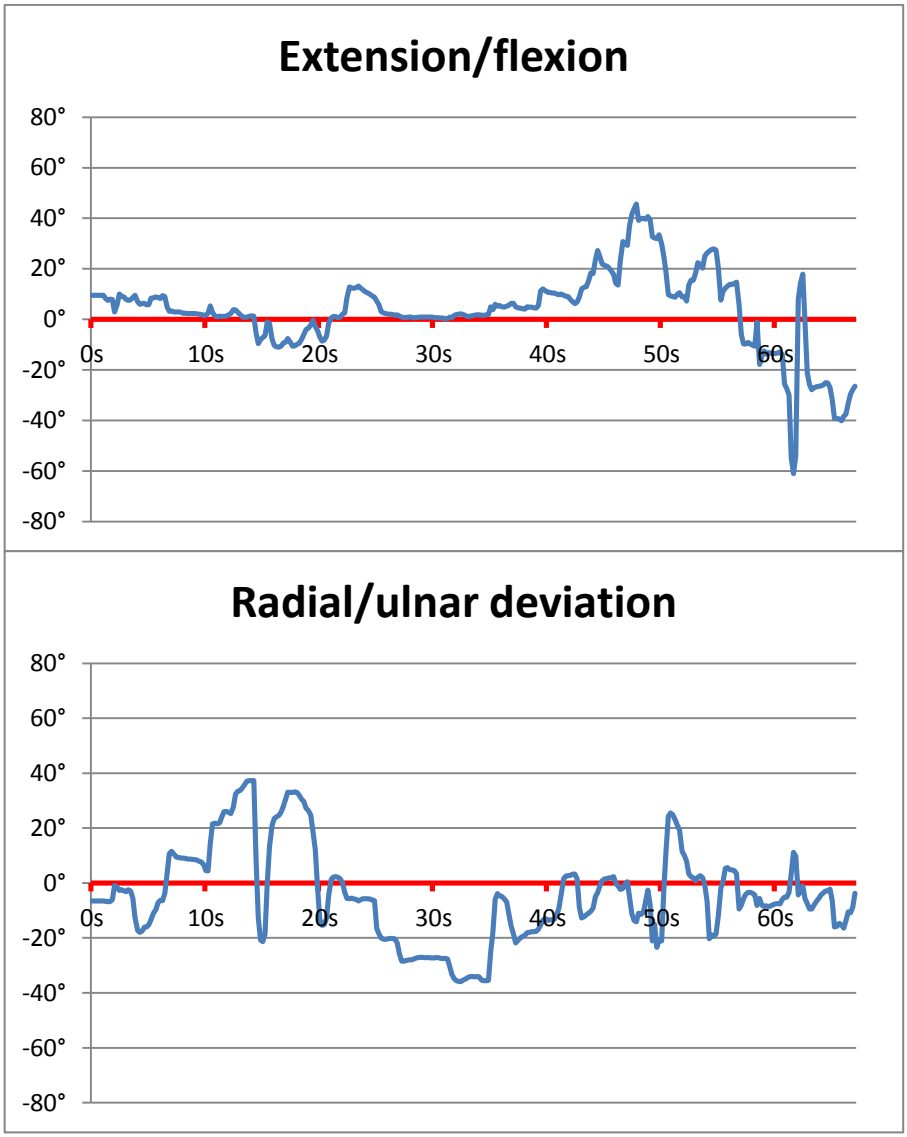

Figure 5.25 First performance of S1 playing to the one hand mode of the flight simulator

Finally, we tested the ski game. Figure 5.27 shows the performance of S1 playing to the deviation mode, while Figure 5.28 shows her performance with respect to the flexion/extension mode. The first thing that we notice looking at both plots is how the new random generator that we implemented creates more uniform levels. The flexion and extension movements are well-alternated and

the same goes for the deviation movements, following a sine wave path. Another thing that we notice from both the plots is that the positive peaks are generally greater than the negative ones. The positive peaks easily reach close to 40°, while the negative ones are closer to 20°. In both cases the positive values of the plots are associated to the skier moving to the right, meaning that S1 had perform a wider movement in order to reach the far right side of the track. This disproportion of the positive and negative movement is due to the ranges of motion calculated in the tuning session. In fact, the position of the skier on the screen is associated with the angle of the hand with respect to the extremes of the wrist's range of motion, hence if an extreme is smaller than the other, the player has to perform a shorter movement in order to reach the relative side of the track.

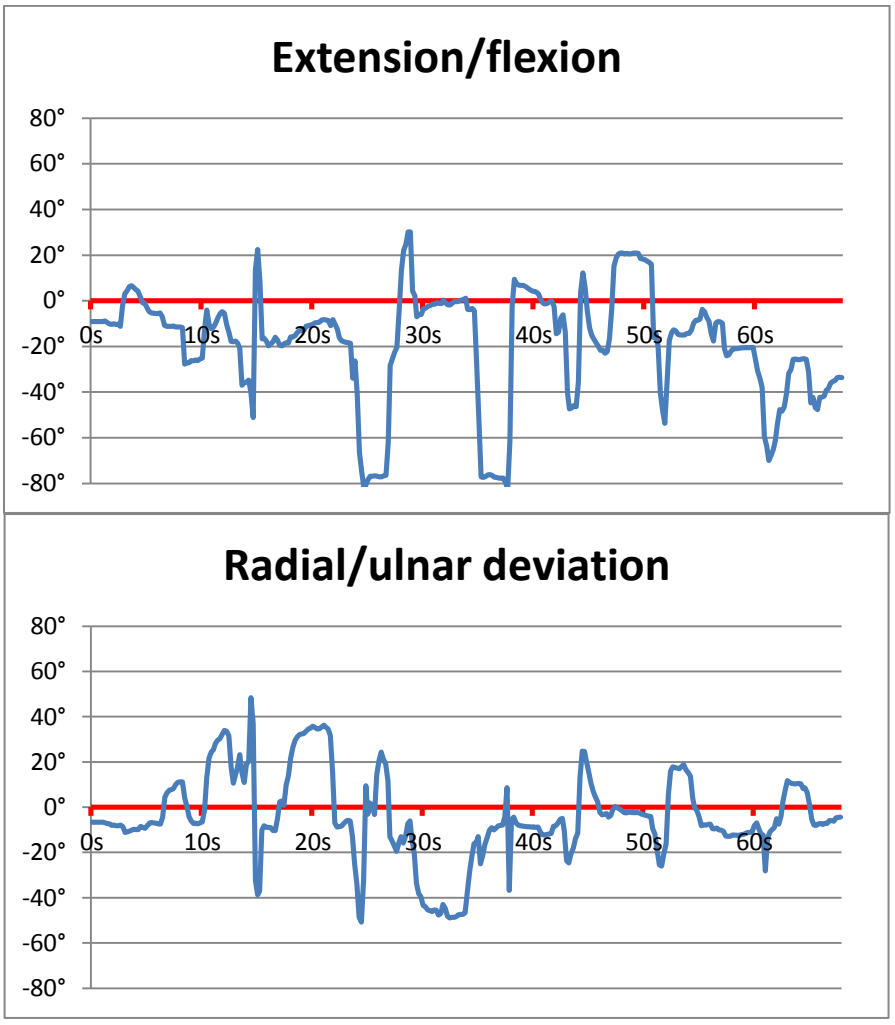

Figure 5.26 Second performance of S1 playing to the one hand mode of the flight simulator

S1 performed good in both the runs scoring 740 out of 800 in the first one and 760 out of 800 in the second one, meaning that she respectively passed through thirty-seven and thirty-eight targets out of forty. Apart from some stabilization issues due to the horizontal speed of the skier movement, she did not have any problems playing the game.

5.4.4 Final remarks

S1 had almost no problems playing the designed games. The ones where she performed better was the plane simulator and the ski game. Even though she said that she preferred the one hand mode over the two hands one, she achieved a perfect score in both game modes, meaning that she performed a good exercise. Also in the ski game test she performed a good exercise, achieving an almost perfect score in both of its game modes. The one that she found harder was the rhythm game. Apart from the final score, she had issues timing the movements of both hands in order to push the buttons at the right time. Finally, despite the final scores, she performed quite well in the Flappy Bird-like game, being able to go through half the level the first time that she played to the game, and improving her score in the second test.

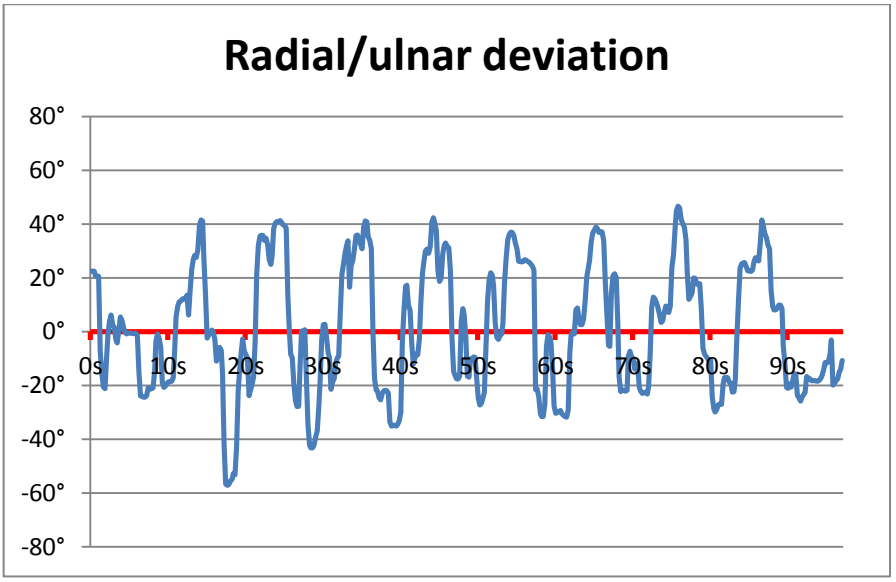

Figure 5.27 Performance of S1 playing to the deviation mode of the ski game

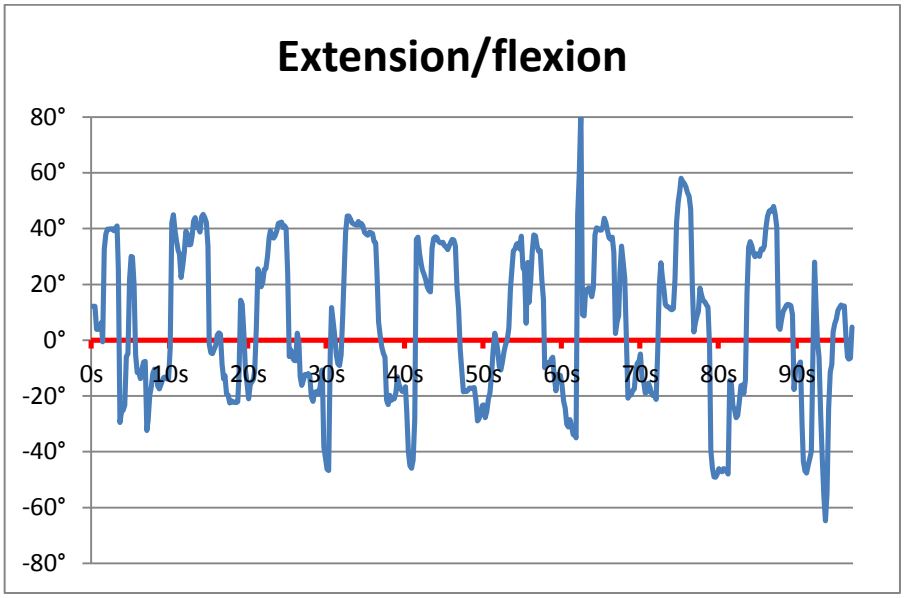

Figure 5.28 Performance of S1 playing to the flexion/extension mode of the ski game

5.5 Fourth experimental session

In this experimental session we continued the evaluation of S1's performances. We asked her to play again all the game modes tested in the previous session, using the same settings. The session lasted about half an hour.

The tests of this experimental session were performed using the general setup described in Section 5.1. We used the setup with the wedge as a support, since in the previous session we noticed that the subject's hands were too close to the LMC during the flexion movements. Also the therapists suggested to use a wider surface to lay the forearms, to prevent the subject from tilting back and forward her arms. We put the notebook and the LMC on the same medical bed used in the second session. The subjects sat on the same bench, as well. We adjusted the height of the bed in order to respect the distances defined in Section 5.1.

In this session, as in the previous one, we used the version 2.1.0 of the Leap Motion SDK. We used the same flight simulator custom level used in the third experimental session. We also used the same pre-set level for the rhythm game. Finally, we used the random generator to create the Flappy Bird-like

and ski levels. For each random generator we set the same parameters used in the previous session. We also set the same difficulty levels and in-game parameters for each game as they were set in the third session.

5.5.1 Tested game modes

We tested all the four designed games. S1 played twice to the rhythm game and to the continuous mode of the Flappy Bird-like one. She then played twice the one hand mode of the flight simulator and twice again to the one hand mode. Finally, she played once to the deviation mode of the ski game and once to the extension/flexion mode of the same game..

5.5.2Data analysis

Since the games were in their final version and both the therapists and the subject already gave us their feedbacks in the previous sessions, no particular feedbacks were given this time, so now we focus on data analysis.

We tested the games in the same order of the third experimental session. The first game that we tested was the Flappy Bird-like one. Figure 5.29 shows the plots of the two performances playing to the continuous mode.

S1's first performance in this session was worse than the first of the previous session. She passed through only four couples of pipes out of twenty. In the second run she performed better, getting a score of eleven out of twenty. Despite this improvement, she could not be able to reach her highscore of thirteen scored in the previous session. This probably means that the Flappy Bird-like requires more training in order to acquire a certain level of skill. Focusing on the movements of the hand, we notice from the plots in Figure 5.29 that the transitions from one movement to the other are gradual, allowing the subjects to perform a continuous movement throughout the game.

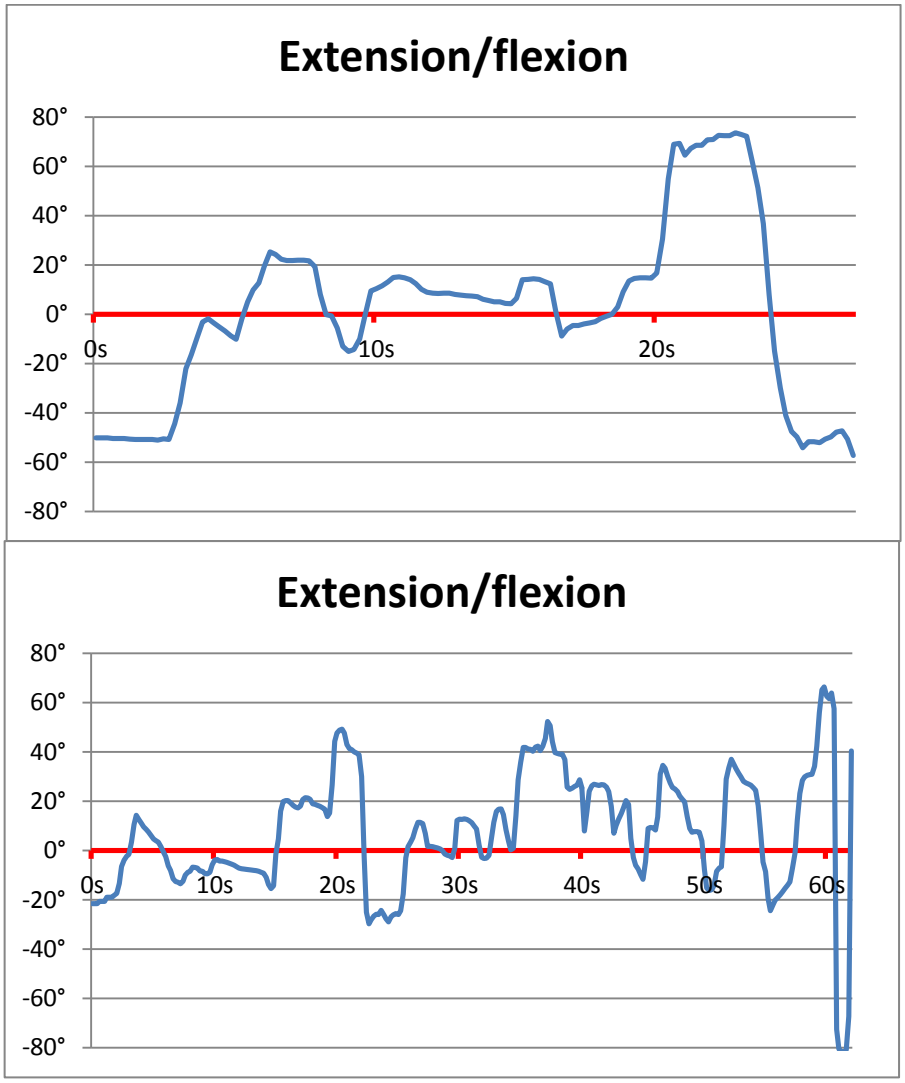

Figure 5.29 Performances of S1 playing to the continuous mode of the Flappy Bird-like game

The next performances are those relative to the rhythm game (Figure 5.30).

Unlike the performances with the Flappy Bird-like game, those involving the rhythm game went better than the ones in the previous session. We noticed while watching S1 playing that she were more confident and understood better how the game works. This can be also noticed by comparing the scores of this session with those of the third one (Section 5.4.3). In this session's first run she scored 800 points out of 1320, correctly pushing forty buttons out of sixty-six, while in the first run of the previous session she scored 680 points. In the second run she improved her highscore of twenty, resulting in 820 points (forty-one buttons correctly pushed). In the same run of the previous session

she scored only 420 points. This results show how S1 is gradually becoming familiar with the gameplay, being able to slowly improve her performance. We will see in the following sessions if she will keep this trend.

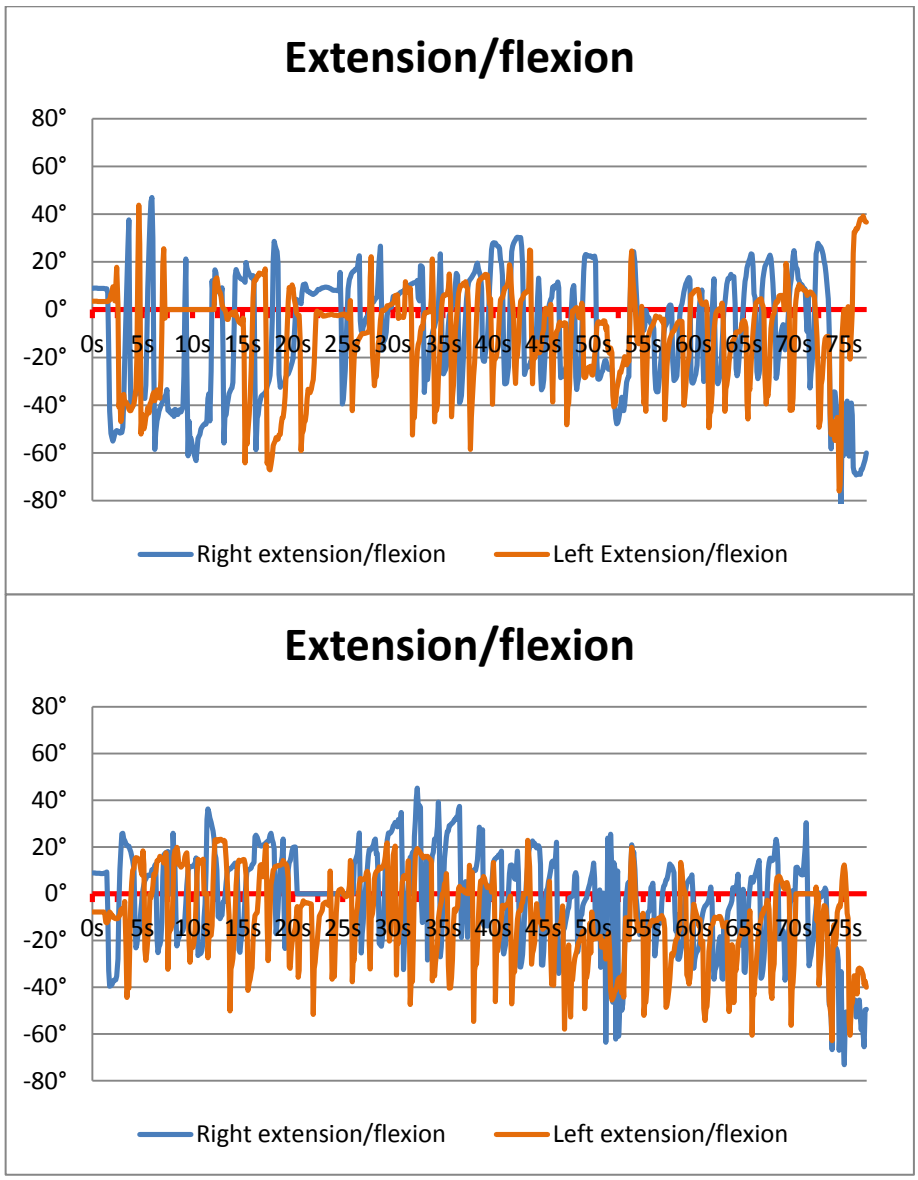

Figure 5.30 Performances of S1 playing to the rhythm game

Figure 5.31 to 5.34 show S1' performances while playing the flight simulator. The first two figures are relative to the two hands mode, while the last two are relative to the one hand mode.

The plots in Figure 5.31 and 5.32 confirm the ability of S1 to coordinate the movements of both hands in order to play to the game. Indeed we notice that

the trends of the left and right hand movements are similar in each plot. Also in this experimental session, S1 scored 440 points out of 440 playing to the two hands mode. This means that immediately understood the gameplay and had no problem in performing the exercise created by the therapist. This also means that the game is so intuitive that the subject is able to keep her level of skill stable during time, without performing any training sessions.

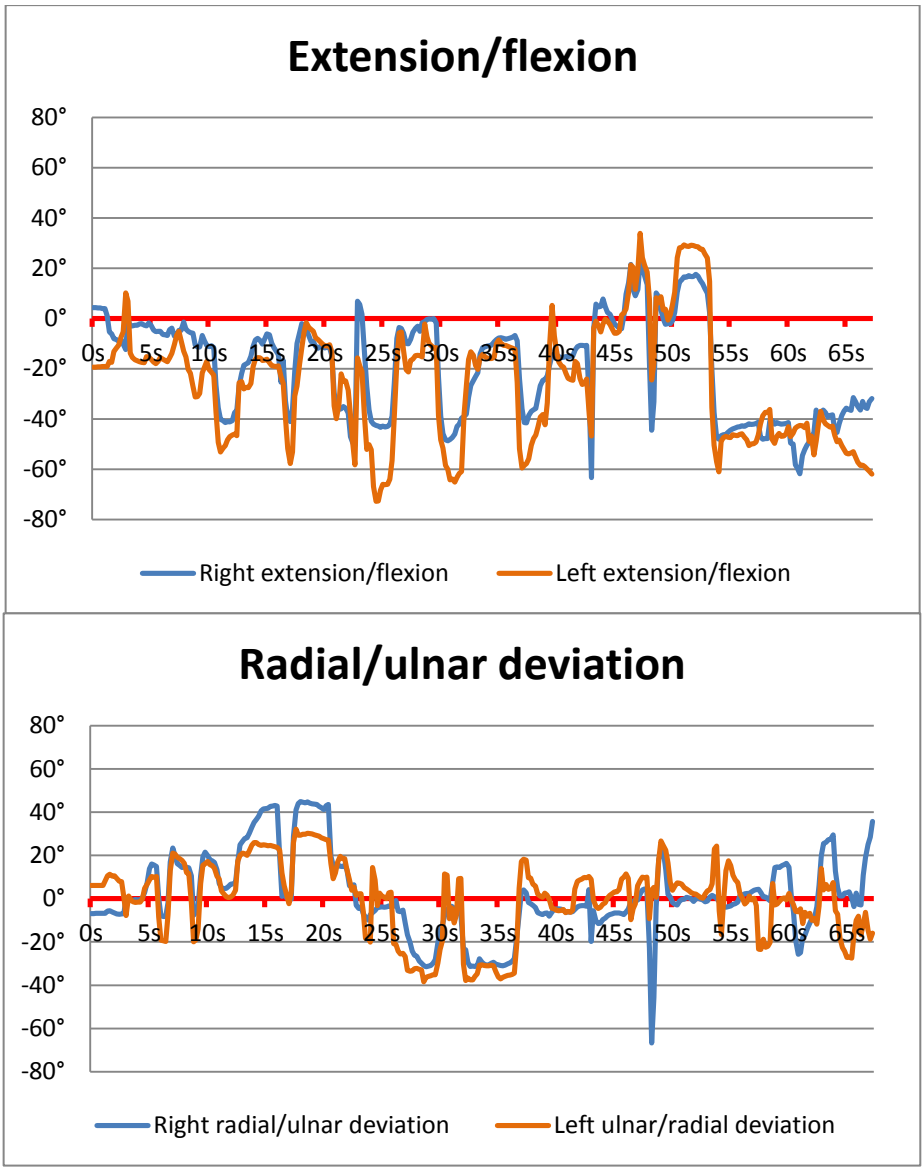

Figure 5.31 First performance of S1 playing to the two hands mode of the flight simulator

S1 also reached the maximum score in the two runs of the one hand mode of the flight simulator (Figure 5.33 and 5.34), proving how she definitely mastered all the game modes.

Finally, we present the plots relative to S1's performances while playing to both the deviation mode (Figure 5.35) and the extension/flexion mode (Figure 5.36) of the ski game.

Her performances in both game modes were similar to those of the previous session, settling on high levels. She scored 740 points out of 800 in the first run and her highscore, 780 points, in the second run.

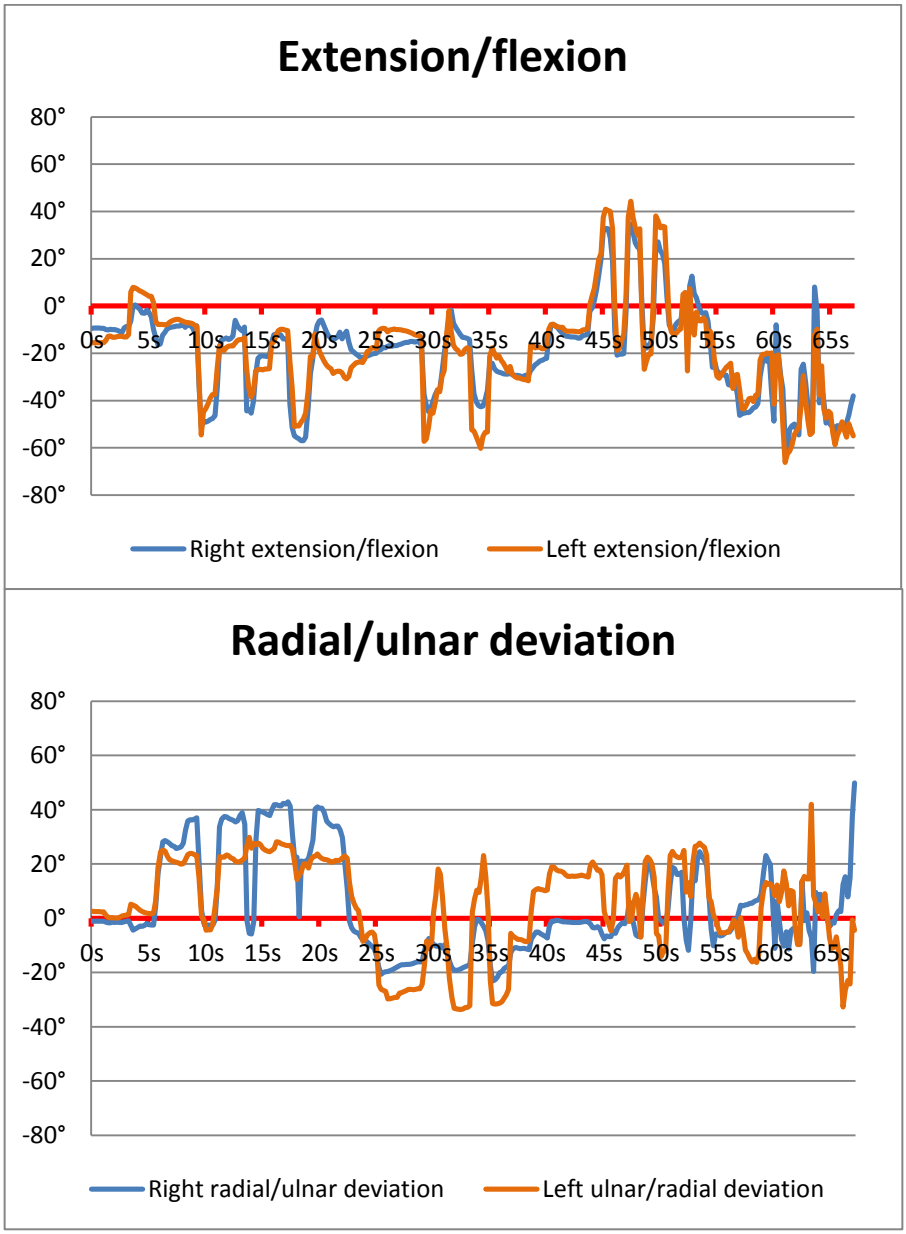

Figure 5.32 Second performance of S1 playing to the two hands mode of the flight simulator

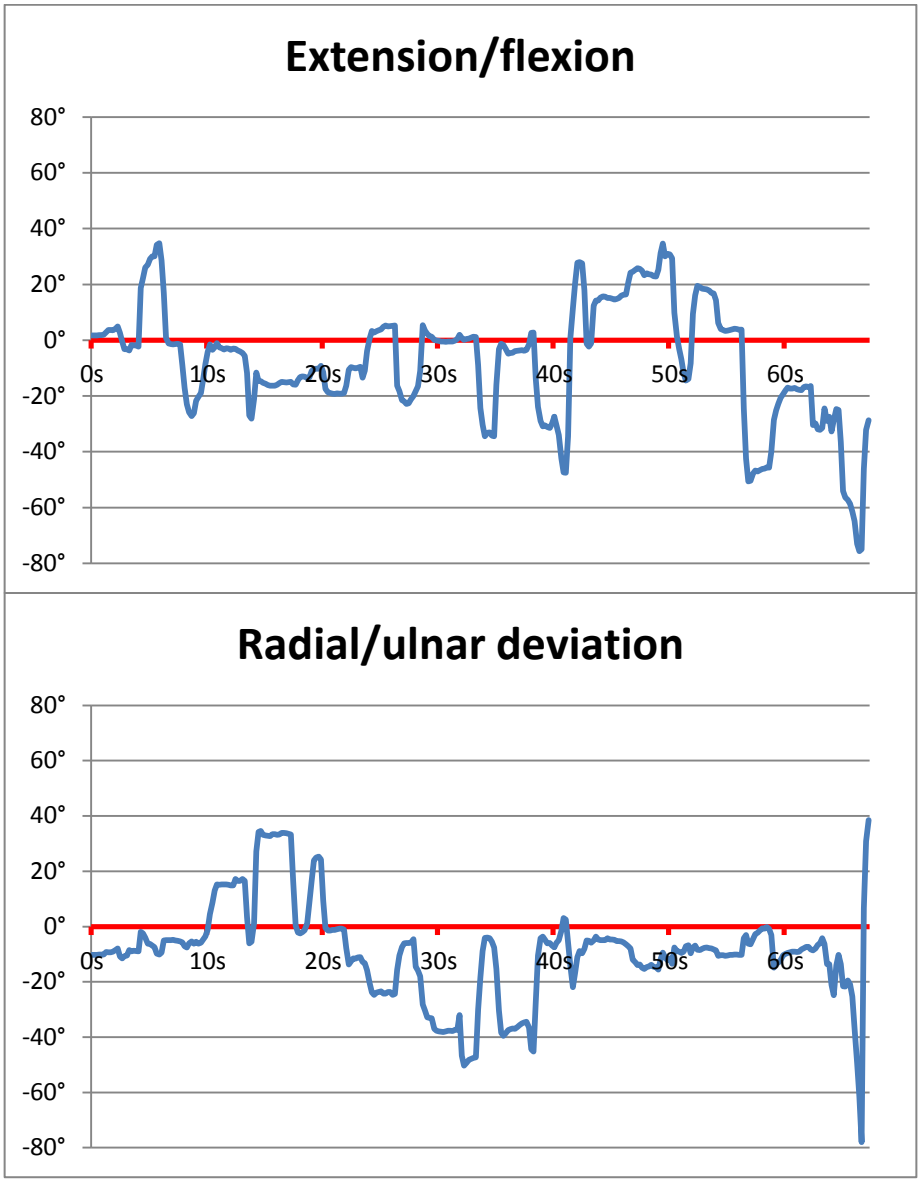

Figure 5.33 First performance of S1 playing to the one hands mode of the flight simulator

This results show that she became confident with the gameplay, keeping her scores high throughout both the sessions. At the same time, combining the feedback of the score and the plots we can see how she focused in order to perform well and while doing this she performed a good gradual exercise, that alternated both ulnar and radial deviation movements in the first run (Figure 5.35) and flexion and extension movement in the second run (Figure 5.36), allowing her to reach ranges of motion of ±40° in the first case and between ±50° and ±60° in the second case.

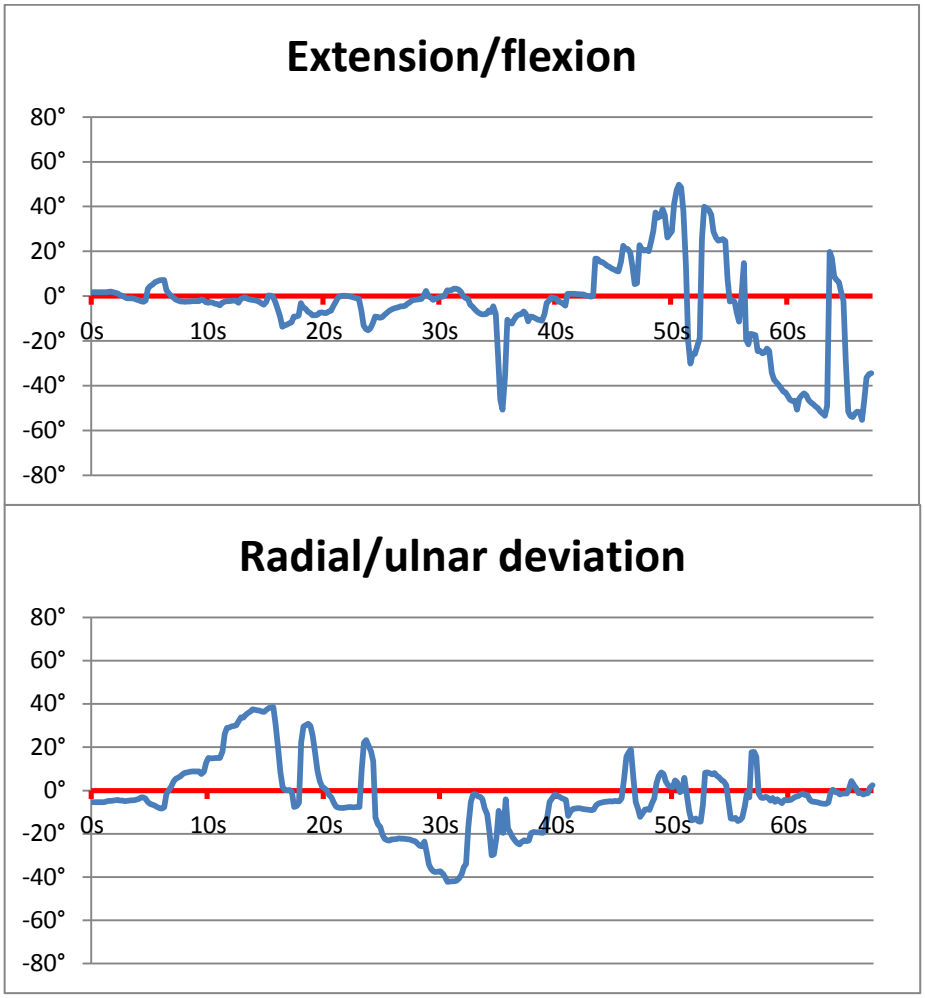

Figure 5.34 Second performance of S1 playing to the one hands mode of the flight simulator

5.5.3 Final remarks

In this experimental session we analyzed the performances of S1 comparing them with those of the previous session. We noticed that the Flappy-Bird like game is the most hard to get used to. Scores in this game did not improved throughout the experimental sessions. Moreover, in the first run of this session, S1 reached a lower score with respect to all the other runs both from the same session and from the previous one, suggesting that a training session could be useful before exercising, in order for the patient to get used again to the gameplay. Instead, S1's performance with the rhythm game improved in this session. She became familiar with the gameplay, getting higher scores than the ones that she got in the previous sessions.

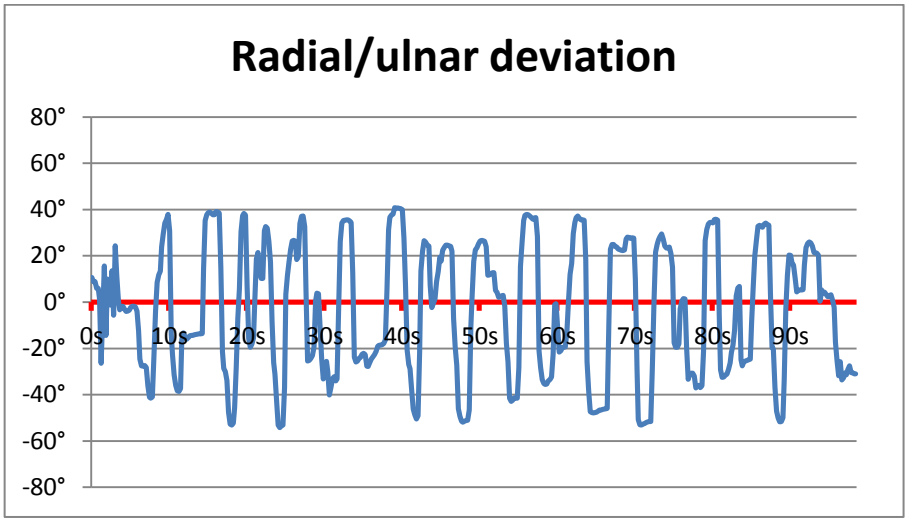

Figure 5.35 Performance of S1 playing to the deviation mode of the ski game

S1 also confirmed her skill in playing to the ski game and to the flight simulator. She reached again the maximum score in both the game modes of the flight simulator and near to the maximum scores in both the ski game modes. In particular in the plots of the ski game performances (Figure 5.35 and 5.36) we see that in order to reach such high scores, she performed a good exercise, gradually alternating the movements in each direction.

This is the last experimental session performed before writing this document. We will perform other sessions in order to analyze how S1's interaction with the games evolves in a long period of time, after several runs.

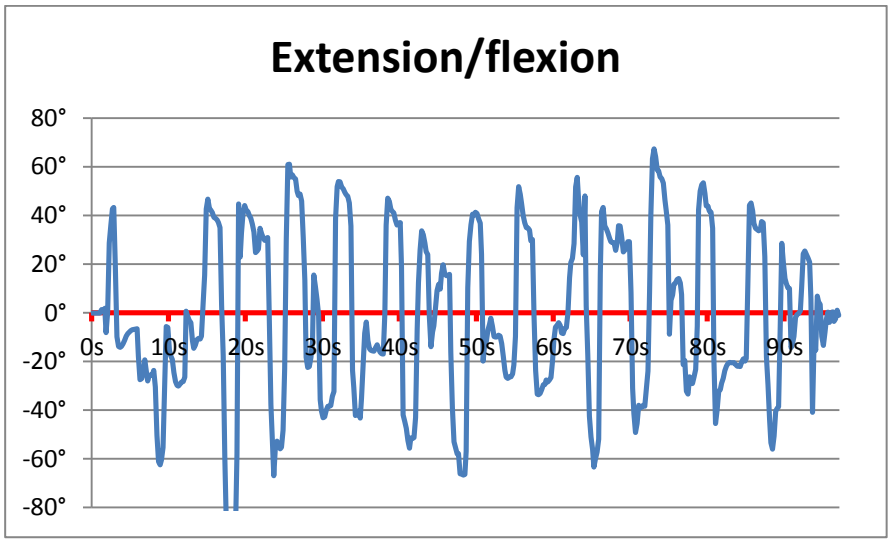

Figure 5.36 Performance of S1 playing to the flexion/extension mode of the ski game

Chapter 6

Conclusions and future work

The goal of our work was to design a set of rehabilitation games that could help the patients affected by Juvenile Idiopathic Arthritis performing their physical therapy. We wanted to create games both useful and entertaining, that would encourage the patients to perform their exercises, thus preventing them from quitting their rehabilitation process. In order to achieve our goal, we used an iterative design approach, that is, we designed our games, and then we followed a cyclic process of prototyping, testing and analyzing our designs, in order to improve the final outcome.

We designed different types of games in order to greet the tastes of a wide range of patients. We mixed both general game design rules and specific rules for rehabilitation games. General game design rules were applied to our games in order to make them entertaining, while those specific for rehabilitation games helped us in designing useful games from a medical point of view.

The feedbacks that we received during the experimental sessions validated our work. The patients liked the games and suggested us some additional changes to make them more appealing. The therapists also were satisfied with our design. They were glad to see how easily the patients performed their exercises by playing the games. Furthermore they confirmed the usefulness of some specific features, such as the replay mode or the built-in data collection system, for the evaluation of the patients' therapy.

During the experimental sessions we received also some useful feedbacks for future work. Other game modes will be added to the games. For example, the

therapists asked for a game mode for the rhythm game that would focus on the extension movement. Right now the difficulty of the games is statically adapted to the patients' ability using the level creation modules, in future work we look forward to dynamically adapt the difficulty during the game in relation to the patients' performances. We consider also the possibility to create a website that collect all the patients' highscores, with charts that allow the patients to compare their performances with those of their friends. By doing so we would like to use the challenge factor to encourage the patients to play the games and, so, perform their exercises. Another feature that we are considering involves the use of the webcam to see live the patients while they are playing. The webcam could also record the patient's performance, giving the therapist a second visual feedback in addition to the replay. Finally, more games will be designed in order to cover all the exercises presented in Section 3.3.2 and more experimental sessions will be performed in order to analyze how the patients adapt to the games.

Appendix A

Collected data

In this section we present the data collected throughout the last two experimental sessions. We divide the section in two sub-sections, one for each of the experimental sessions run. For each table containing the data we add a reference to the figure containing the relative plot.

A.1 Third experimental session

Figure 5.24 – Right extension/flexion

-2,002465	3,004974	-21,33669	-13,55305	-10,9797
-2,013438	2,91449	-20,75938	-13,21557	-13,8159
-2,013438	2,874237	-21,46856	-13,10196	-13,4284
-2,013438	2,823486	-21,80863	-10,94623	-12,2962
-2,013438	2,887146	-21,81656	-10,30834	-13,8877
-2,759988	3,0242	-21,46251	-8,936192	-10,2778
-1,947752	3,088989	-20,30098	-8,293515	-9,09965
4,662018	2,505219	-19,9245	-11,09992	-6,06299
2,005432	2,058563	-19,9352	-11,07751	-2,66506
2,90567	1,758698	-14,81833	-9,760756	-1,38173
2,679993	2,223236	-11,84644	-10,23921	-1,86771
3,488739	2,18573	-11,35891	-9,740751	-2,2233
3,099976	2,029358	-6,46546	-10,87045	-1,74775
1,915466	2,508575	-5,169482	-8,480186	-2,40502
1,23114	2,308807	-6,828606	-7,867772	-0,59619
0,9960938	1,98172	-10,63047	-3,821479	0,578949
3,751984	-7,363678	-8,940997	-1,524473	3,287231
7,747711	-5,79567	-8,173711	-2,03164	-1,40045
5,108185	-6,41534	-9,055022	-6,150095	2,452148

3,885559	-3,857028	-8,08798	-14,4205	5,311432
2,968506	-2,647281	-9,385876	-13,04255	-0,47905
3,012329	3,58313	-8,545416	-11,87709	-1,27504
2,605225	-2,026954	-6,909081	-13,59443	-4,10027
1,768188	-8,436964	-6,486712	-12,70204	-6,2277
1,642853	-13,05627	-7,744002	-10,51751	-4,19539
3,071381	-16,17093	-8,747974	-6,040746	-3,35182
2,368103	-20,34893	-8,164088	-5,166834	-2,47469
3,032593	-21,3596	-15,92135	-6,246998	-3,02033
3,275208	-20,62085	-19,61859	-6,40347	-3,65283
3,260437	-20,39008	-16,08829	-2,43318	-6,04555

-7,81624	-22,163	23,21478	-16,1093	-44,5469
-8,32978	-19,2925	27,15244	-18,189	-44,0029
-8,30069	15,99588	28,43268	-18,9081	-48,9669
-7,37978	26,61594	31,7868	-19,2392	-37,5607
-7,70731	22,63257	32,14618	-19,0214	-33,4853
-9,47994	20,349	38,42731	-18,8866	-25,3869
-10,1979	17,30038	37,74091	-18,4218	-28,6063
-10,8685	11,13739	39,99872	-16,6183	-25,7846
-8,70068	6,689484	35,68481	-16,7799	-24,7143
-6,77837	4,223877	37,74796	-11,1131	-25,7611
-6,16814	3,402771	38,37836	-4,26762	-33,6936
-3,0748	8,056244	21,01086	-5,76922	-41,3331
-2,11053	7,662201	12,09921	-1,72408	-46,1166
-2,95672	8,285919	2,424896	-3,48194	-44,1783
-4,81854	4,564636	16,05591	-2,97642	-50,1422
-7,34884	-0,35947	17,94022	-2,28358	-43,0963
-7,7275	15,28705	17,62338	-0,54532	-36,5914
-6,76276	16,29257	15,16379	-2,06893	14,07874
-3,40386	5,091156	11,578	-2,70078	25,23813
-2,97508	0,998169	10,87198	-4,14187	14,45905
-1,44457	-0,0394	2,071045	-4,22219	6,868866
-1,47148	-0,20203	-0,05226	-4,32366	-1,83167
-0,17877	-0,21689	-2,41351	-6,75297	-9,12306
-1,38187	-0,66934	-0,89283	-3,68259	-12,2552
-0,04513	-0,44421	17,72241	-3,5478	-11,1818
0,474335	-1,2927	20,01157	-1,63504	-8,11983
0,699097	-2,07293	19,78708	-11,7769	-6,93507
-0,48285	-2,47289	18,56656	-7,44791	-5,94856
-11,0362	-2,3782	21,47287	-6,89956	-6,35818
-23,6571	-3,22319	21,10474	-7,48779	
-36,0172	9,999878	18,1528	-7,21523	
-39,3293	23,2655	16,03076	-6,87486	
-41,1284	26,44153	14,02969	-6,62024	
-39,9447	29,26956	7,583099	-8,441	
-44,5888	27,73474	-1,47483	-11,5732	
-51,8746	25,96002	-4,31046	-15,0194	
-44,7552	32,97153	-5,61849	-10,6394	
-30,4957	32,43512	-7,32798	-20,7252	
-23,4341	27,7554	-12,6102	-22,2165	
-21,7456	24,22687	-16,1085	-37,6168	

Table A.1 Right wrist extension/flexion of S1 while playing to the two hands mode of the flight simulator

Figure 5.24 – Left extension/flexion

1,017242	-1,639629	-11,33613	-20,16422	10,16501
1,006775	-0,3828253	-9,849458	-22,63496	9,707062
1,006775	0,2666321	-10,17284	-24,56247	4,306702
1,006775	2,006439	-9,517876	-24,56222	-7,83613
1,006775	4,43512	-5,218721	-22,25303	-3,67117
0,7965088	4,226105	-1,738824	-16,23917	3,143311
1,909485	-2,003059	-2,491078	-15,67058	15,15341
2,274261	-6,661394	-6,495445	-14,99045	17,71918
2,44223	-10,76572	-10,82366	-11,62981	20,17368
1,410706	-13,55067	-8,821626	-10,72554	16,55524
0,8992615	-16,77225	-5,391587	-10,63298	1,315125
6,273712	-24,62255	-5,741412	-10,30936	-0,98773
12,55984	-24,81962	-4,905726	-11,2935	-1,41772
5,155731	-22,39463	-2,484611	-10,88207	-3,21455
1,38327	-18,33817	-3,898142	-5,515834	-4,64201
0,8157349	-20,79853	-4,927605	-4,684792	-6,07167
2,763916	-21,10148	-4,032556	-4,915304	-7,55255
10,38318	-22,85211	-4,365292	2,626526	-12,4137
7,785339	-23,78392	-4,695051	0,943573	-32,6829
6,370575	-24,6578	-5,912146	-0,6166568	-45,501
6,787567	-25,65349	-6,852921	-6,062843	-67,233
6,579773	-26,17366	-6,093219	-3,804569	-53,9388
5,01767	-26,28326	-4,567659	-4,030158	-55,2381
3,144073	-26,47085	-2,659657	-5,15647	-52,3141
2,807159	-26,45838	3,17746	-6,518966	-66,6593
5,907684	-26,97634	1,034973	-5,968202	-67,9945
10,02051	-24,23769	1,570404	-3,33138	-64,0332
11,04181	-23,71481	0,5406494	-3,301022	-67,6615
3,801819	-23,63437	-11,67978	-5,130455	-48,6426
2,25531	-22,58726	-25,05434	-8,492103	-45,7612
1,730377	-21,93172	-19,59459	-8,35374	-53,9016
5,644958	-19,29842	-21,98149	-7,377188	-37,4505
5,770905	-15,49598	-22,54684	-5,994222	-7,36846
3,181458	-9,699131	-11,46679	-2,832523	-4,97012
1,965118	-11,3141	-11,16487	-2,788947	9,64859
6,417175	-10,14919	-0,4536087	-1,960153	5,524689
7,850922	-13,5288	-0,6823508	-3,744448	3,083771
4,513062	-12,61459	-1,534207	-4,662373	0,885132
-4,580205	-13,90488	-6,982	-3,560447	-0,52549
-4,203943	-12,15702	-18,96687	4,544037	-0,36408

-0,16226	35,71869	-2,12559	-45,6391
3,926117	18,24347	-0,28811	-59,3919
2,355103	8,565582	-0,75157	-59,0408
1,897919	3,726654	3,007294	-59,6116
2,028534	20,25006	4,682434	-56,5967
1,124603	20,08527	3,7771	-56,7917
10,70523	22,40588	-8,16811	-24,7592
5,46524	21,97702	-12,5539	-37,7551
-0,49117	19,23141	-15,2258	-37,7654
-2,77732	14,01422	-15,4481	-32,704
-2,96264	11,96265	-12,6711	-32,9284
-2,89805	11,41336	-12,9362	-39,1587
-2,57556	10,71701	-9,20642	-43,4835
-2,3167	11,00125	-7,82659	-29,6239
-1,74944	22,09033	-8,25201	-10,1228
-1,78006	20,01349	-7,55279	-7,0095
-3,43016	18,12439	-16,4682	-7,26335
-5,37308	18,23669	-15,3853	-9,15151
-5,42242	20,00903	-20,4569	-11,6253
-5,46279	21,8349	-20,2996	
11,20511	21,14597	-25,8351	
25,8389	20,50082	-35,4762	
27,78336	18,03278	-35,841	
25,62704	15,05716	-50,0208	
26,99738	5,811707	-49,1864	
29,51343	2,861298	-58,1097	
29,55273	1,691864	-84,7729	
31,18048	2,803864	-68,105	
30,66666	2,540741	-90	
32,61514	-1,69724	-90	
29,04196	-3,78412	-83,8569	
39,40811	-5,49332	-80,4035	
43,00638	-4,54285	-82,051	
42,39307	-2,63553	-86,5605	
43,28464	-2,01926	-23,3754	
44,24896	-0,88253	-28,2258	
40,1456	-1,81487	-40,9961	
40,08389	2,092743	-40,911	
41,41348	3,581665	-44,1105	
38,3739	0,728912	-44,5284	

Table A.2 Left wrist extension/flexion of S1 while playing to the two hands mode of the flight simulator

Figure 5.24 – Right radial/ulnar deviation

3,004506	32,46552	57,14964	14,22458	18,48014
3,04878	32,63363	57,26244	12,39803	17,36978
3,04878	31,84708	55,09776	12,72846	15,12957
3,04878	32,01342	54,72762	12,2036	9,883938
3,04878	32,029	53,51572	4,443636	1,551178
2,757885	31,60606	53,94576	-2,224609	-2,73938
2,886729	-6,861542	53,0741	-5,255707	-2,86893
3,960158	-15,61246	42,01898	-10,20166	-4,06171
2,268703	-16,98376	30,21519	-12,99078	-11,3487
2,450928	-15,98853	19,64744	-13,76538	-14,9196
6,295901	-15,14435	13,39623	-9,416962	-15,962
8,779497	-10,19852	11,9499	-7,375153	-15,3945
9,065905	9,658504	12,98269	-12,92587	-15,0356
9,57029	23,08319	34,24759	-14,18433	-15,9803
9,337682	27,88709	48,70949	8,825938	-17,2867
9,101564	32,05818	52,81319	21,58938	-20,2989
7,193936	32,82558	52,31973	29,01264	-20,0125
4,653526	34,57979	50,43652	26,34732	-13,06
5,901543	34,8419	50,50491	23,71448	16,71163
5,407656	34,33485	50,03369	12,98219	24,99514
6,177845	34,93192	50,40191	7,766079	31,82418
6,159647	35,01506	51,79903	7,930223	34,39964
6,495035	34,73996	51,32671	6,570791	28,11218
7,866523	35,66359	51,65258	-0,5823975	24,5154
10,75326	35,39624	52,4519	-9,940552	26,06818
15,47513	35,42998	53,31302	-13,57095	15,91029
22,92291	37,45165	53,03232	-14,83035	32,02665
30,98575	38,21202	52,94057	-15,88885	8,444889
35,25887	40,26441	44,56932	-17,13477	4,841335
34,93905	43,40648	20,48876	-22,75827	5,663739
32,63406	44,23824	11,71497	-24,34949	4,843963
31,65757	51,02793	11,56717	-24,70065	2,724374
30,87285	58,96252	11,73802	-24,14404	-12,2284
30,80519	61,48787	13,28025	-23,25189	-16,8439
30,96629	60,99096	19,67739	-22,45468	-20,0244
30,91459	58,8711	32,31047	-21,45813	-18,9687
31,46628	57,78563	34,1799	-21,44644	-18,995
32,40725	58,93343	35,26786	-21,28052	-20,2509
33,4616	58,77614	33,72876	-9,225372	-20,2702
32,59822	55,80353	25,58053	8,643522	-21,2908

-20,6489	10,9039	18,83531	8,907952
-23,1134	10,1141	23,35016	3,580378
-21,0117	8,794448	30,29957	1,841573
-19,2328	8,235265	32,94857	6,676263
-20,8412	14,77451	34,7925	-2,26349
-23,742	16,09226	35,6919	5,812551
-11,4696	16,84419	21,88792	-7,25971
17,13788	16,59995	6,289812	0,079768
34,27099	16,40151	4,609007	-28,6732
41,14577	14,59452	4,796636	-30,9818
43,88584	11,50751	5,912043	-31,598
44,06405	7,38966	5,883523	-32,2349
43,94021	6,281454	7,329719	-36,2589
44,18665	5,657679	9,316387	-43,1372
44,73672	15,28552	10,32714	-47,7636
45,38365	19,26834	12,53431	-53,7122
48,01605	21,06495	16,11098	-56,3533
48,87789	22,57943	13,69764	-56,1507
48,31079	23,44359	14,55832	-54,0234
46,68196	23,52308	14,3513	
31,78448	20,97778	13,61235	
16,91568	18,01412	12,96359	
15,24373	15,94292	12,10381	
13,54731	12,58396	13,17559	
13,92079	9,213514	13,54661	
13,92884	7,538036	13,85041	
15,08955	6,525786	13,05021	
10,27976	6,638494	20,30841	
9,80278	6,442183	26,91348	
9,228766	8,594056	30,9592	
8,5064	8,92145	26,24546	
7,140945	8,763241	27,10935	
6,931916	9,162678	23,43523	
6,454657	9,612062	19,84337	
5,101361	10,15533	21,3275	
12,80703	10,60988	18,32484	
10,74038	10,89617	21,54338	
10,61797	13,90191	20,31279	
10,28529	8,673182	19,48129	
10,89037	16,3188	16,7269	

Table A.3 Right wrist radial/ulnar deviation of S1 while playing to the two hands mode of the flight simulator

Figure 5.24 – Left radial/ulnar deviation

29,15112	36,93621	52,035	-6,220795	15,97379
29,15141	36,8328	51,46981	-14,40421	13,86889
29,15141	36,61121	51,46115	-16,20175	-0,05292
29,15141	36,53315	50,34028	-18,33401	-25,5953
29,15141	36,68644	48,08022	-20,83685	-28,9942
29,31234	36,0351	49,31068	-26,40012	-29,3675
28,45371	-10,1355	48,67306	-23,72366	-33,435
28,11897	-17,37286	46,20774	-19,09949	-31,8957
28,44	-20,73135	44,61568	-16,59357	-32,4316
27,09361	-19,24579	35,77893	-16,10294	-31,3084
22,59385	-14,89392	28,72001	-15,46973	-21,1279
17,1744	-3,092438	27,70388	-14,26929	-21,5233
14,57498	19,7983	28,36796	-18,67627	-22,028
8,485826	31,34128	42,45325	-18,86176	-21,618
11,45238	33,27564	47,38495	2,22509	-21,747
12,45301	34,42643	47,68459	30,70115	-22,5757
13,27777	34,78391	47,35003	32,2559	-22,239
14,2531	35,02499	47,04659	29,19148	-22,0718
14,46998	34,83398	46,74725	22,06265	10,50203
15,86987	35,21453	46,76867	-1,451172	25,55674
17,06212	35,48703	47,23676	-16,73175	35,52758
17,51431	36,16959	47,57854	-18,82245	14,45635
18,00943	36,39843	47,56836	-19,09714	11,40089
18,36185	36,29853	47,81329	-19,59891	20,05364
18,20321	36,28532	50,82813	-20,07181	9,003331
18,5968	36,77102	52,62538	-19,68655	16,40815
33,67987	37,97681	52,62093	-19,75766	14,11044
39,24091	39,58552	52,15388	-19,49527	1,736315
39,70602	41,24063	38,29366	-21,48532	36,62299
38,58353	41,09042	2,770397	-25,09671	39,51429
35,78901	41,13117	2,238257	-26,19705	44,26745
35,30769	43,38663	-3,594025	-25,86362	65,13966
35,06947	48,09966	-2,813812	-25,47461	53,23485
34,78151	49,29983	7,017763	-24,55875	46,74779
34,32546	50,38419	11,9233	-23,99594	1,885092
34,34376	50,22947	33,12215	-23,94009	3,161677
35,08043	49,2263	41,2688	-22,83258	4,728265
37,59956	47,93069	44,94338	-21,03241	5,901904
38,1167	49,10936	35,56412	-7,988159	5,79416
37,4226	51,06884	2,423934	13,2799	5,324615

5,488307	16,89231	35,44304	34,67448
6,872099	24,8054	37,74075	75,39988
8,727252	22,57596	39,84597	76,53876
10,29784	20,23863	40,3589	76,6572
9,339733	20,6232	41,34335	88,41564
10,4088	20,78485	41,50368	91,8845
20,05926	19,20884	31,77575	109,4833
25,97711	16,70739	9,243155	102,0117
37,52023	15,45319	8,689568	68,30053
40,22723	15,93518	6,891944	86,62686
40,73484	16,78115	8,284389	80,65295
41,20149	17,57205	8,466474	87,24371
41,48312	17,36636	11,63843	87,96393
41,58275	19,06837	13,29925	-18,6902
41,62849	30,77194	15,41723	-47,6813
42,07349	35,11412	18,93033	-48,3644
42,87241	34,93436	18,27183	-46,3821
43,18656	34,42545	17,16117	-45,0708
42,71533	34,62644	14,87389	-43,8722
42,61362	36,126	9,634676	
31,75931	33,75296	5,599032	
6,694578	29,40117	11,90638	
7,42521	27,01136	10,42154	
9,182116	27,0874	53,78561	
9,793909	25,9543	20,75657	
9,709786	24,55486	17,46457	
14,18029	23,41168	-24,2015	
14,55351	23,08481	-1,35843	
15,47609	23,65074	25,0253	
13,00403	22,8991	12,38492	
13,51942	23,03699	95,54153	
11,18131	23,04475	56,90985	
12,33887	22,78197	54,73235	
14,01189	21,87895	28,84745	
14,51691	21,55683	46,86443	
15,04815	21,48647	35,37346	
14,56446	21,52373	33,15761	
14,87675	27,47075	36,69147	
17,09722	34,23392	37,96199	
16,55647	35,77896	42,01766	

Table A.4 Left wrist radial/ulnar deviation of S1 while playing to the two hands mode of the flight simulator

Figure 5.25 – Extension/flexion

9,596283	2,46521	-10,3069	10,93597	1,975098
9,596283	2,399475	-10,8576	10,57373	2,06012
9,596283	2,317719	-10,9377	9,905823	2,158295
9,486633	2,27713	-10,5887	9,269135	1,99054
9,486633	2,351563	-9,29259	8,729828	1,508362
9,486633	2,268951	-9,071	7,219238	1,081329
8,333649	2,240021	-7,56025	5,742676	1,281555
7,540405	2,032745	-8,76608	3,035431	1,480713
8,026703	1,894226	-10,5889	2,603302	1,696716
7,94635	1,531952	-10,477	2,259583	1,764374
2,94223	1,733643	-9,80057	2,117065	1,852661
5,814514	2,437103	-9,41482	2,003235	1,735779
10,01929	5,337433	-7,99099	1,96521	1,526245
9,186188	2,658447	-6,09556	1,536102	1,752777
8,866394	1,333374	-4,04304	1,810791	1,93515
7,928101	1,043457	-3,5283	1,262115	4,948242
7,528656	1,287415	-2,28497	0,911713	3,837341
7,71106	1,197662	-0,34003	0,683777	6,001495
8,695343	1,223602	-2,71842	0,788147	5,218903
9,550079	1,298035	-4,4185	0,867554	5,427979
7,008057	1,827454	-6,95436	0,899414	4,956146
6,025787	2,283905	-8,5271	0,722168	4,908813
6,254333	3,873444	-8,18811	0,721314	5,17215
6,312195	3,753418	-6,67881	0,804321	5,565857
5,795624	2,772644	-1,51813	0,916962	6,362885
5,899658	1,971924	0,645905	0,900513	6,365814
8,449158	0,99057	1,147369	0,906311	4,96521
8,546234	0,736298	1,001709	0,88266	4,638977
8,933685	0,985352	0,617035	0,914825	4,431641
8,623138	1,178925	0,984253	0,871124	4,155792
8,271301	1,382233	2,032135	0,756378	4,07959
9,37851	1,367279	2,53717	0,644989	4,991791
9,062195	-5,46313	8,707367	0,62738	4,859436
5,035645	-9,52585	12,88062	0,577148	4,811798
3,218018	-7,95309	12,48593	0,521118	4,645111
3,33197	-7,23298	12,33276	0,299591	4,499237
2,984528	-6,36347	12,5397	0,251831	5,451263
3,009491	-0,92797	13,17401	0,920319	11,31808
2,907867	-1,55561	12,34479	0,678406	12,02542
2,78363	-7,86411	11,74969	1,519043	11,29382

10,78	39,21478	13,8913	-26,3634
10,69229	39,96561	13,79019	-25,902
10,43692	39,90134	14,23944	-25,0618
10,40427	39,63351	14,76041	-25,1952
10,03687	40,68472	5,763489	-26,9545
9,77713	39,42072	-6,09381	-31,7466
10,09732	32,69159	-9,75274	-39,2342
9,484863	32,1947	-9,65669	-39,1852
9,143127	31,9873	-9,14237	-39,3301
8,971436	33,44537	-9,75784	-40,0618
7,897766	29,95862	-10,2202	-38,3966
7,014221	24,91101	-10,6154	-37,4033
6,29361	18,23648	-1,1474	-33,1156
6,855652	9,729401	-17,7935	-29,6019
8,946198	9,336761	-14,625	-27,8193
12,08771	8,971741	-12,4956	-26,4643
12,70984	8,826416	-13,7706	
12,99829	9,953735	-13,1333	
15,33215	10,5347	-13,4115	
18,41815	8,877594	-13,3605	
18,10986	9,01358	-13,4563	
23,47717	7,200104	-13,2343	
27,30927	13,55215	-12,8414	
24,90894	15,49017	-14,0536	
21,94974	15,49536	-25,5892	
21,30817	18,27652	-27,5051	
21,12344	22,4827	-29,8178	
20,31607	21,75348	-54,9427	
19,13928	20,30704	-60,9447	
17,73553	25,14612	-54,0155	
14,20782	26,27426	8,092163	
13,58521	26,95459	14,49237	
23,15833	27,70911	17,95468	
30,85663	27,85812	-1,37492	
30,06268	27,34506	-21,0721	
29,33646	20,53345	-25,8442	
37,32349	7,622498	-27,8516	
41,6203	11,18536	-27,0459	
43,79614	12,30692	-26,7418	
45,60422	13,17459	-26,4059	

Table A.5 Wrist extension/flexion of S1 while playing to the one hand mode of the flight simulator

Figure 5.25 – Radial/ulnar deviation

-6,55209	9,058486	23,52555	-5,70279	-35,5691
-6,55209	8,949739	24,10682	-5,67566	-35,8179
-6,55209	8,766096	24,56354	-5,79446	-35,8811
-6,54886	8,698968	25,71078	-6,22595	-35,3731
-6,54886	8,66734	27,90126	-6,4566	-34,9582
-6,54886	8,521703	30,36841	-16,5721	-34,4071
-6,64682	8,33492	33,06824	-18,5237	-34,0708
-6,72446	7,957226	33,00137	-20,0264	-34,1075
-6,72305	7,67819	33,00726	-20,4225	-34,1793
-6,09799	6,687037	33,20183	-20,5497	-34,0982
-0,78372	4,516305	33,00775	-20,3393	-34,2213
-1,58182	4,372561	31,87948	-20,1634	-35,2988
-2,7558	14,43511	30,55277	-20,1733	-35,5683
-2,52139	21,55317	29,69469	-20,4175	-35,5583
-2,75729	21,77887	27,26469	-21,7856	-35,4652
-3,15308	21,55089	26,39193	-25,8848	-25,0291
-2,41422	21,8822	24,64037	-28,4693	-17,7015
-2,92773	24,15051	18,48687	-28,4384	-5,93707
-5,46277	25,97367	12,17882	-28,2048	-3,82977
-12,6845	26,05674	-1,54456	-28,0506	-4,69629
-17,2592	25,77869	-13,2442	-27,9717	-4,85516
-18,0069	25,29682	-15,4128	-27,7651	-5,71597
-17,505	27,56442	-15,1191	-27,3734	-6,83713
-16,1205	32,38117	-12,9656	-27,2148	-11,446
-16,0158	33,47549	-4,29742	-27,0978	-15,7286
-15,2266	33,67262	1,430243	-27,0999	-18,5089
-13,357	34,58924	2,205323	-27,1438	-21,83
-11,1143	35,78807	2,358781	-27,1279	-20,9321
-9,64157	37,04639	2,023535	-27,1337	-20,1071
-7,17593	37,34742	1,463623	-27,2449	-19,4753
-6,30487	37,32056	0,133189	-27,2423	-18,9872
-6,47458	37,3028	-3,39783	-27,1887	-18,0362
-3,71246	8,454885	-5,56635	-27,2385	-17,9276
3,334776	-12,8467	-5,69199	-27,3945	-17,7702
10,6858	-20,8009	-5,52264	-27,4753	-17,7004
11,57792	-21,3023	-5,80277	-27,468	-17,609
10,6309	-18,6069	-5,93427	-27,6956	-16,785
9,415291	-0,00499	-6,51019	-30,4197	-15,2752
9,28686	13,30113	-6,1073	-33,4011	-13,5001
9,047896	20,97606	-5,68924	-34,8189	-12,9435

-13,4857	-10,9784	4,884237	-4,3436
-13,4351	-11,4784	4,801423	-3,62766
-13,4234	-10,737	4,476882	-2,98331
-13,215	-6,63422	3,341769	-2,78256
-11,6931	-2,60953	-9,47012	-2,23322
-9,20853	-7,84985	-8,08432	-6,48447
-4,34113	-21,0739	-5,62064	-16,0091
1,636097	-15,0404	-4,04993	-15,7548
2,582496	-23,4004	-3,4317	-14,7289
2,65898	-20,7409	-3,44556	-15,254
2,820354	-21,1071	-3,78278	-16,4433
3,244719	-2,20038	-4,29144	-13,6575
3,22594	12,13698	-8,14301	-10,4893
1,506361	24,32505	-5,56726	-10,8162
-8,8306	25,5637	-8,09164	-8,92014
-12,7623	24,77649	-8,57843	-3,77655
-12,2292	23,10546	-8,28821	
-11,5671	21,06493	-8,63202	
-11,0108	19,18489	-8,35239	
-10,2864	11,48102	-7,91803	
-9,10339	9,981263	-7,64435	
-5,01718	7,965195	-7,47577	
-3,53491	3,258059	-7,61331	
-1,03708	2,272059	-5,90704	
0,769665	1,796994	-5,15518	
1,50617	0,827194	-5,17056	
1,64203	2,137873	-3,36762	
1,902236	2,619205	3,459813	
1,962994	1,91809	11,20503	
2,285238	-0,82684	9,818099	
-0,16275	-6,67596	-4,37827	
-1,1015	-20,256	-2,95905	
-2,38406	-18,8651	-1,12244	
-1,94736	-19,3683	-5,70114	
-0,39478	-18,5779	-7,53366	
0,495197	-12,0537	-9,49466	
-5,3638	-1,84125	-9,48169	
-11,2443	0,535017	-8,03998	
-13,6888	5,365904	-6,82919	
-14,1281	5,628733	-5,59369	

Table A.6 Wrist radial/ulnar deviation of S1 while playing to the one hand mode of the flight simulator

Figure 5.26 – Extension/flexion

-9,05812	-11,446	-19,8188	-40,73	-0,89192
-9,05812	-11,7276	-18,9599	-66,6187	-1,75092
-9,05812	-27,8003	-17,9784	-74,789	-1,76271
-9,04778	-27,1826	-15,9422	-81,9778	-1,14796
-9,04778	-27,1834	-17,1621	-80,6844	-0,1912
-9,04778	-26,1991	-19,536	-78,1749	-0,39893
-8,77967	-26,3398	-19,7556	-76,8873	-0,06639
-9,46027	-25,9649	-18,8271	-76,8374	0,249146
-10,0553	-26,1826	-18,3953	-76,6709	0,630798
-10,2984	-25,5393	-18,5094	-76,7883	1,085846
-10,1074	-25,0298	-15,8348	-77,0976	-3,78116
-10,346	-12,6074	-15,8727	-77,1503	-3,86949
-10,1861	-4,09464	-15,2392	-76,6856	-3,37918
-11,1735	-10,1692	-13,7917	-76,3807	-4,3591
-2,1094	-12,1598	-13,1966	-61,8414	-27,2146
3,038391	-11,8139	-12,9308	-28,2835	-51,575
4,412354	-10,0129	-12,7454	-25,3867	-77,1101
6,15979	-7,64236	-11,1119	-22,5919	-77,3924
6,680511	-5,79664	-10,8595	-20,2902	-76,9441
5,764435	-4,70799	-10,6202	-4,32338	-76,2641
4,876221	-5,42808	-10,2641	13,2341	-76,1856
4,221771	-10,4091	-9,5935	22,08029	-76,529
1,903076	-13,6906	-9,57264	24,73505	-77,2454
-0,86468	-17,7526	-9,38533	30,12836	-77,3149
-1,11649	-17,873	-8,38912	30,18964	-77,6122
-2,86807	-17,7035	-8,25793	4,222504	-77,6755
-4,77968	-18,4995	-8,45653	2,250061	-77,7019
-5,29497	-20,5505	-8,66567	-6,95781	-79,4531
-5,48761	-36,9668	-10,8646	-6,00055	-82,4042
-5,58988	-35,9424	-8,2512	-6,03805	-61,4716
-5,53095	-35,6571	-10,3333	-3,44356	-2,5373
-5,28597	-34,7147	-12,421	-3,27208	9,484772
-6,99807	-40,2731	-16,1058	-2,3494	7,469238
-10,7736	-51,132	-17,4791	-2,06554	6,842987
-11,1592	13,74268	-17,9024	-1,56027	6,697449
-11,1778	22,48425	-18,2121	-1,51687	6,708405
-11,1952	8,702179	-18,3375	-0,84028	6,318573
-11,1124	-16,6572	-18,6886	-1,08592	5,640808
-11,4582	-16,3615	-33,8909	-1,2345	4,923767
-11,5211	-17,6256	-26,3458	0,270813	4,415833

4,02179	20,92322	-14,4483	-25,7637
3,852417	20,48245	-17,5909	-25,4474
2,762909	20,81418	-9,76688	-25,3086
0,366974	20,43628	-9,06685	-25,703
-1,07465	20,68558	-9,26302	-31,1013
-1,39469	20,86322	-9,88854	-44,7378
-1,10504	20,96997	-20,9409	-42,284
-0,42214	20,72806	-24,0935	-46,8176
-0,11088	18,49164	-23,6351	-47,7176
-2,47009	18,31467	-22,0044	-42,2799
-14,4904	17,90585	-21,0718	-42,2254
-13,6772	17,46658	-21,0236	-41,7225
-7,53257	16,85019	-20,8409	-39,1905
-6,16829	16,04147	-20,7851	-38,4323
-13,6344	-16,0611	-20,5621	-35,9559
-40,3653	-14,0955	-20,5617	-35,2875
-47,4245	-20,0905	-20,3868	-34,9064
-46,9285	-40,3845	-20,547	-33,6549
-45,8174	-48,0345	-20,4174	-33,519
-46,4254	-53,6514	-20,4182	-33,5897
-35,5129	-35,5659	-25,6901	
3,814148	-17,3641	-30,85	
12,27866	-13,958	-33,8766	
5,72287	-12,7552	-37,9159	
-4,68113	-13,1849	-59,5618	
-11,8887	-14,7344	-63,5345	
-15,243	-15,0305	-69,9123	
-16,9907	-14,9137	-67,7389	
-18,3224	-14,9885	-65,0966	
-19,9218	-14,3267	-61,35	
-21,646	-14,2502	-53,7286	
-21,5534	-12,8972	-47,6681	
-22,9046	-9,8597	-48,3174	
-22,3361	-8,55153	-46,4873	
-16,7038	-8,53465	-40,7204	
-3,56528	-7,95169	-31,7986	
14,98804	-3,82912	-30,1839	
18,8045	-4,78291	-25,705	
20,42688	-7,28576	-25,5543	
20,97806	-8,96359	-25,8342	

Table A.7 Wrist extension/flexion of S1 while playing to the one hand mode of the flight simulator

Figure 5.26 – Radial/ulnar deviation

-6,62421	11,12428	-8,84442	-34,0845	-44,634
-6,62421	11,18148	-9,09088	-48,6151	-48,1989
-6,62421	4,101749	-10,3351	-50,8184	-48,8901
-6,60809	0,311171	-10,3666	-31,9214	-48,7276
-6,60809	-4,38376	-4,89758	9,499693	-48,602
-6,60809	-6,25922	2,454728	-3,1124	-48,3682
-6,86685	-7,19345	2,727081	1,780197	-47,5301
-7,19128	-6,99387	0,87823	0,630694	-47,3352
-7,39496	-7,3103	9,759514	-3,28809	-47,4005
-8,00333	-6,87192	13,872	14,28023	-46,6441
-7,89972	-6,47992	21,66349	20,51144	-37,435
-8,12827	-1,12332	26,53092	24,29233	-28,7482
-8,25455	13,2151	29,62319	21,07453	-21,7365
-7,97635	21,59783	31,18692	19,04495	-16,109
-8,68521	24,33679	32,09163	11,55064	-15,5278
-11,1421	25,4919	32,40525	-12,9923	-13,0341
-10,8964	28,17588	32,53178	-14,9379	-25,0062
-10,6072	29,62267	33,57275	-17,138	-21,3633
-10,1905	30,23269	34,58923	-19,5776	-16,4128
-9,78775	32,18538	35,00726	-15,7635	-13,4282
-9,90729	34,01373	35,73746	-13,0647	-10,2144
-9,86365	33,56012	35,19748	-15,8787	-8,97397
-8,48584	31,62448	34,58121	-12,9334	-9,96753
-8,96872	17,77438	34,6953	-7,31131	-9,16809
-9,2952	10,57662	35,45824	-6,03714	-8,25922
-8,16324	14,38936	36,22637	-14,4566	-8,01703
-7,06174	17,68684	35,3376	-19,8799	-7,91571
-6,75525	23,27662	34,47426	-33,475	-4,33649
-6,92712	15,10665	31,75673	-38,1449	8,710616
-7,02856	10,86137	15,60193	-39,672	-36,8139
-7,34375	19,28699	-6,87277	-43,3881	-5,4548
-7,51489	20,15061	-8,73737	-44,0237	-4,36658
-4,54364	48,36631	-8,64923	-45,4602	-6,94394
4,372801	36,94592	-8,26627	-45,6204	-7,91608
6,409273	-32,3512	-7,24738	-46,0803	-8,18002
7,494031	-38,8102	-6,2515	-45,3597	-8,40009
7,861355	-37,006	-5,83667	-45,5325	-8,41235
8,189276	-10,2204	-6,11722	-47,6219	-8,62753
10,03782	-8,24548	-12,8326	-46,9954	-8,55362
11,10735	-8,85681	-25,1131	-42,931	-8,69367

-8,78558	-1,58673	-7,52542	10,447
-8,94745	-2,39887	-9,49057	10,38795
-8,82303	-2,58853	-9,61292	8,276702
-10,8131	-2,17996	-9,25263	8,4385
-12,141	-2,25748	-10,0232	6,417822
-12,2359	-2,39465	-10,2429	1,144183
-11,9746	-2,38956	-10,5985	-5,34164
-11,8451	-2,40448	-12,7928	-7,89966
-11,6421	-2,59869	-12,8183	-8,09622
-8,51447	-3,11469	-12,8075	-7,28458
-8,15299	-3,37109	-12,3331	-7,24478
-7,13333	-3,65888	-12,3313	-7,64029
-5,34378	-3,89899	-12,4256	-6,99313
-4,89929	-4,12271	-12,4999	-7,16977
-10,6598	-9,51651	-12,2172	-5,97226
-23,5655	-11,8554	-12,0801	-5,8941
-24,6349	-19,2534	-11,6616	-6,14883
-20,4771	-25,4321	-11,1398	-4,6485
-18,0379	-25,9611	-11,1469	-4,46414
-13,8855	-20,458	-10,8786	-4,31326
-11,4554	-16,2458	-8,11533	
13,10635	5,328598	-6,86658	
24,71027	15,96064	-9,55237	
24,64467	17,8255	-11,6882	
20,29598	17,62542	-12,289	
15,76242	17,24116	-28,0887	
10,76514	16,96638	-13,626	
7,016594	18,0015	-10,9692	
4,572916	18,77147	-9,90585	
2,445265	16,5799	-9,06641	
-2,24713	15,2941	-5,05277	
-3,33472	13,67451	-7,52628	
-3,08197	4,071361	-3,99872	
-2,84622	-0,2323	2,618691	
-4,37387	-1,34061	7,532722	
-3,71835	-4,1705	11,73599	
-0,9028	-8,12576	10,89681	
0,225864	-7,75623	10,50047	
-0,32184	-7,93103	10,35421	
-0,87943	-7,6373	10,29728	

Table A.8 Wrist radial/ulnar deviation of S1 while playing to the one hand mode of the flight simulator

Figure 5.22 – First run

-2,1619	41,69238	34,60843	19,73111	2,425262	-5,28248
-2,15157	46,50818	37,16397	21,03781	1,06546	-2,07074
-2,15157	48,99908	40,54449	21,73935	-0,22751	7,051056
-2,14688	60,89499	41,32797	21,79175	-2,38162	18,06952
-2,14688	61,48444	41,62122	26,68054	-7,94556	24,15329
-2,14688	60,65897	41,97806	27,15576	-12,7293	29,19681
-2,13596	64,70251	41,76718	26,98322	-14,2645	29,63049
-2,13596	54,93628	40,66867	26,94717	-15,6145	29,79373
-2,13596	54,59641	40,47882	26,93289	-18,5348	30,72797
-2,1121	54,20462	40,29819	26,92407	-17,2694	30,78348
-2,1121	51,77219	31,22086	26,29459	-18,281	30,69403
-2,05601	40,17566	17,91995	23,31839	-15,6995	30,66895
-1,91076	15,37933	18,36981	27,04141	-10,8806	29,74939
-1,74862	3,294281	19,55817	26,90384	-0,15019	27,38077
-1,5743	1,289124	19,41461	26,06052	9,409729	26,14362
-1,48269	-1,27156	19,39114	26,28641	9,850098	25,47345
-1,31705	-2,23089	20,05786	26,37714	9,167725	19,26834
-1,12544	-2,3935	21,64639	8,743561	9,155731	16,65674
-0,86226	-2,4167	23,73273	-20,7038	9,153198	16,31714
1,666046	-1,97329	26,02475	-26,0537	9,151947	14,97919
3,145233	3,877014	28,75198	-26,8832	9,151276	6,660339
2,694397	10,2319	37,15503	-25,2293	9,150787	-3,25453
-0,05934	16,7131	41,03561	-22,0653	7,039795	-3,95271
0,784546	19,29041	39,79074	-11,6818	3,391785	-4,87321
0,591705	20,03592	37,62756	-8,13513	2,701019	-4,84033
1,704376	22,87451	30,17374	-10,3368	-3,89001	-4,82233
3,148224	32,64038	25,66589	-13,4763	-6,45303	-4,38287
3,472565	36,06796	24,20703	-15,5871	-8,38987	4,408844
2,717255	37,25073	21,79825	-15,8115	-9,32999	15,47629
3,04599	36,39029	20,16254	-3,85038	-9,77276	28,1597
3,39679	33,01071	24,51852	5,639587	-9,82191	40,87625
3,287628	29,58902	34,46631	4,008514	-8,10672	47,66617
3,730774	27,18823	41,5379	5,084106	-6,48048	47,28754
2,825989	22,78397	42,86646	3,935394	-6,4742	47,12341
2,21286	16,44586	43,19272	8,352966	-6,39554	46,37616
1,791412	6,220581	45,45346	14,72485	-6,05858	45,5224
3,829895	6,684448	43,01486	13,92438	-5,78295	45,02686
12,08405	10,88629	34,49017	10,77896	-5,50121	45,14902
28,37613	17,90085	27,19504	5,647186	-5,39048	45,25165
38,85751	26,39343	17,13742	3,447266	-5,32243	45,39575

Table A.9 Wrist flexion/extension of S1 while playing to the Flappy Bird-like game (first run)

Figure 5.22 – Second run

-9,65025	14,68277	28,95566	-5,21186	-13,0849
-9,65341	21,96329	28,61191	-5,52027	-15,5452
-9,65341	24,57181	28,7352	-4,26509	-15,7752
-9,65438	25,22308	28,47525	0,480225	-15,7653
-9,65438	26,70038	27,63779	11,68497	-15,4711
-9,64797	27,34616	24,99927	19,30399	-15,0428
-9,64797	27,64133	14,50241	22,37796	-14,819
-9,64797	27,20163	-0,24138	23,3924	-14,3136
-9,64046	26,28192	-7,76273	24,15384	-14,2016
-9,64046	25,19366	-9,5298	23,85583	-14,0015
-9,64046	24,23132	-9,762	23,34369	-13,5639
-9,63306	13,98718	-9,76597	23,0972	-5,81329
-9,57202	2,186584	-10,9789	22,89993	11,18768
-9,54029	-14,5113	-26,361	21,38187	15,03558
-9,56378	-17,593	-35,816	12,40079	12,63361
-9,60992	-20,0826	-38,7086	-3,57658	12,69287
-9,60477	-18,8309	-41,2129	-11,3866	12,36603
-9,58157	-17,327	-41,6434	-18,8331	12,2749
-9,54219	-14,667	-42,1654	-27,0414	12,85455
-9,63138	-7,5984	-42,7203	-29,3853	14,32333
-8,21562	1,967102	-42,4782	-27,7626	14,61819
-9,50601	2,711639	-42,5372	-23,7103	14,4812
-8,97104	3,04361	-41,1304	-17,5925	13,43155
-9,03451	2,677185	-39,8651	-11,1381	6,71167
-8,96834	2,994781	-38,2418	-8,42897	-0,69534
-8,82383	5,657227	-32,5335	-6,69389	-6,79953
-8,53571	6,794312	-20,8672	-6,70641	-12,5981
-7,99538	5,712006	-4,56638	-7,11046	-17,7042
-7,9947	4,772583	-4,97424	-7,41418	-17,9707
-6,29452	3,752655	-5,97004	-5,94178	-16,4115
-6,0895	3,241028	-5,6129	0,735962	-13,3934
-4,63714	3,64975	-2,02153	7,175995	-8,40846
-4,51649	4,109558	0,154816	17,69342	-4,1957
-4,55449	5,356079	0,351868	21,98563	-3,63911
-4,51003	16,36481	-0,32995	20,4563	-3,35763
-4,06264	28,01587	-1,82134	16,74075	-3,38818
-3,66881	29,9736	-2,27284	7,755005	-2,63086
-3,21275	31,242	-2,90419	-1,40525	-0,43265
-2,6861	29,41776	-2,80912	-7,05237	1,881378
2,285034	28,97745	-4,02089	-11,0929	4,895935

9,452148	14,25919	-1,43751	18,97028
10,34256	15,03052	7,058716	15,16614
10,23495	15,14822	22,69366	7,090393
10,0954	14,69907	23,30856	4,407349
9,942169	14,27109	19,75693	4,865875
10,13846	14,2316	16,84875	4,901398
9,967712	11,72534	15,52274	4,83783
9,595123	6,574371	13,9476	4,560059
9,163147	4,005646	14,24384	4,134094
8,90979	1,818115	13,22711	3,815125
8,818634	-2,05346	10,83435	2,008484
9,125183	-2,47898	8,218292	-5,07863
13,20117	-1,56418	5,789185	-13,6075
18,6973	-0,52391	4,55481	-17,089
20,86063	2,648346	3,798401	-17,2693
20,91998	3,765686	3,427429	-16,8066
16,47745	3,653931	4,918091	-15,6584
3,427826	3,804626	4,856659	
-8,9564	4,042206	7,698425	
-12,6749	3,111053	19,98279	
-13,0002	2,506165	24,10522	
-14,5347	2,971649	26,81168	
-18,479	2,993561	30,87543	
-18,0609	3,979614	32,8331	
-17,7072	4,815765	34,52734	
-15,6747	6,235779	35,48727	
-14,2816	7,407501	38,81409	
-12,841	7,732117	41,51434	
-10,9411	7,707031	46,93668	
-9,45389	8,4599	48,00992	
-2,67383	9,284271	46,62048	
14,11588	8,758606	47,5914	
21,56329	8,472748	47,5885	
25,92798	8,733124	47,55157	
28,61227	7,864716	47,54019	
26,70724	-7,05052	48,07831	
22,35611	-11,9743	45,61542	
21,14359	-4,9266	38,72043	
19,78531	-3,91688	31,55682	
16,92056	-2,02418	22,28876	

Table A.10 Wrist flexion/extension of S1 while playing to the Flappy Bird-like game (second run)

Figure 5.23 – First run

0,53006	-30,6683	-0,16172	10,68835	16,21457	11,35321
0,40033	-31,3212	4,992218	14,31451	-8,42569	10,8645
0,40033	-30,9454	9,812103	18,30939	-16,7166	10,49597
0,281921	-33,0516	9,821075	-14,4662	-17,7387	9,621918
0,281921	-30,6331	8,499786	-32,1894	-15,8253	9,409332
0,281921	-29,3173	7,676788	-30,0922	-15,1306	9,717041
0,317322	-28,5755	9,509064	-29,6989	-16,0979	9,814575
0,317322	-25,7122	9,243378	-25,8628	-19,4023	9,794037
0,178955	-25,6385	11,0148	-23,4163	-13,4922	9,825226
0,178955	-24,0967	9,540466	-23,4252	16,58493	10,04089
0,178955	-20,6664	8,508911	-22,9984	26,28867	11,6134
-0,53222	-21,2098	8,363739	-23,4688	22,5932	11,37833
-1,00259	-23,297	8,048889	-23,2377	22,09213	11,37729
-1,11226	-23,8048	6,633362	-22,3773	16,61969	11,46719
-0,67128	-23,0786	1,504883	-19,9451	-9,22743	11,61282
-0,05836	-10,2037	-3,70902	-19,0268	-46,4843	11,68353
0,052582	-4,8635	-2,07145	-21,2739	-46,2588	11,86398
0,241333	-3,04492	-1,95852	-20,3781	-38,2388	12,00549
-9,07952	-3,7679	0,204498	-18,4988	-28,8985	12,29547
-33,1636	-8,20751	-4,61066	-18,309	-13,3827	12,64227
-39,9534	-21,6956	-30,0194	8,705902	1,331238	12,75653
-47,4555	-48,7551	-28,895	23,67499	11,27222	12,7027
-46,3085	-52,9961	-33,3618	26,66626	13,50903	12,53064
-42,1306	0	-33,7982	26,5607	14,0007	12,91165
-43,3823	0	-32,1999	25,99954	17,09302	13,69357
-44,2414	0	-32,391	25,17282	21,9516	14,56665
-44,0107	0	-31,5892	24,9025	8,093536	9,917999
-44,4207	0	-30,1397	24,76108	-23,2006	-10,3959
-46,134	0	-30,2484	24,82751	-19,2938	-14,1609
-46,392	0	-29,383	24,58881	-16,2217	-13,1884
-45,6508	0	-29,663	24,6962	-11,3974	-12,7868
-46,2235	0	-28,1138	24,39774	-7,46828	-11,2646
-46,8681	0	-27,3821	23,6694	-2,32952	-10,284
-47,0513	0	-27,1811	22,81729	0,838837	-9,75723
-33,8317	0	-26,6753	22,46225	5,997711	-8,84234
-13,4692	0	-28,7109	22,3576	10,1283	-7,82359
0,322907	0	-28,2421	22,51489	10,10342	-7,59431
-3,25935	0	-23,1176	21,63721	10,57684	-7,65374
-26,5056	0	-14,8244	19,05536	10,55106	-7,26684
-28,9858	0	1,100311	18,30234	11,71466	-6,40604

-5,86563	-4,32967	1,098969	8,443207	-4,88557	34,77328
-5,14306	-4,09267	0,70755	7,661591	-4,12506	35,56567
-0,44959	-4,14137	0,655579	9,12085	0,63559	35,8295
7,474518	-3,97516	0,441376	3,815125	1,308441	36,51514
15,70337	-3,47797	0,507752	-9,17779	5,071777	35,74881
19,21036	3,016479	0,926361	-18,2696	8,262421	31,31863
8,680603	18,1626	3,013916	-17,0787	15,84305	32,67868
-7,91124	22,29529	13,48846	-16,3394	25,98788	31,6308
-7,07235	-7,76283	24,26083	-13,9997	24,12094	23,16409
-6,58051	-22,0763	15,89618	-13,2602	-8,34848	-9,05913
-5,0885	-17,578	-0,75932	-11,7757	-16,499	-8,82801
-4,40451	-15,5909	-0,12899	-9,04893	-19,3687	-7,29452
-3,32066	-10,0064	2,179443	-0,81912	-18,1761	-9,18633
-2,51076	-6,54596	4,118561	8,98053	-17,3236	-7,00921
-1,69524	-5,49631	4,920349	-17,696	-15,9311	-5,08894
-1,06238	-4,00612	6,505859	-23,1133	-14,1161	-0,80016
-0,89887	-3,44285	8,535309	-24,0746	-12,0174	9,851959
-1,08946	-3,19283	8,539642	-20,4014	-7,67088	31,87698
-1,47003	-2,79965	8,191132	-17,0826	3,041962	47,08871
-1,35001	-2,04069	9,023651	-16,3384	22,29449	47,13721
-1,35475	-1,38795	9,587646	-16,1778	27,53928	46,13483
-0,80049	-0,39683	9,849518	-15,8493	27,19492	44,85376
-0,71545	-0,1427	9,992157	-14,8807	28,06848	42,36249
-0,10324	0,255524	10,05109	-13,4937	27,34595	39,24991
-0,27118	1,039612	9,840607	-11,261	27,1637	35,38818
1,787415	2,682434	9,847626	-11,8491	26,48364	32,49869
11,45276	7,213409	11,95901	-10,2563	27,44278	19,86469
27,11411	22,71255	22,83102	1,079956	28,99265	-9,63393
20,94745	12,39511	28,86462	19,04041	5,106506	-12,2617
-9,15431	-13,5027	15,53116	19,54813	-19,0617	-10,3261
-16,7206	-5,54084	-15,332	-23,8118	-17,5665	-8,85147
-14,3097	-3,09627	-12,6884	-25,2869	-16,5156	-8,65788
-12,3627	-2,32821	-9,90566	-25,6352	-15,1065	-6,97899
-9,95419	-1,87066	-12,483	-23,9744	-12,1654	-6,23597
-8,37509	-1,06456	-15,7941	-21,1372	-11,8776	-1,13024
-7,19721	0,085541	-10,9521	-18,7107	-11,634	4,785858
-5,89654	1,040924	-3,5921	-17,6713	-5,10727	6,950928
-5,54814	1,263763	-1,02641	-16,656	-1,7267	8,897583
-5,37685	1,195618	0,296783	-13,6388	4,856079	17,91165
-4,36245	1,108215	5,748199	-8,89716	29,30429	26,49188

27,56128	6,830933	2,131073	-15,7777	32,12701	17,77612
-2,48805	6,821564	-3,69282	-21,9878	32,44876	23,70605
-20,2922	6,413452	-23,4692	-18,4611	31,03519	28,42746
-17,4336	5,432404	-26,8586	-15,8606	29,29868	23,14032
-16,4013	3,740204	-25,4969	-13,11	30,3761	-7,11013
-15,4383	3,606323	-19,8995	-8,65919	9,490417	-8,14588
-15,0686	3,56311	-13,1512	-6,33901	-10,9601	-6,26727
-12,5522	3,605835	-9,71037	0,458313	-7,70601	-0,30548
-9,66111	3,51767	-8,00282	5,450653	-5,42063	4,433838
3,978363	2,528534	-6,94903	14,28873	-2,33252	14,2038
20,51572	1,062592	-5,95639	19,77072	0,977234	23,91705
24,9122	0,458435	-5,95908	23,92999	4,375977	29,29446
25,29535	-0,16877	-7,16369	26,58807	6,498444	30,06754
25,71857	-0,58608	-5,95956	26,49362	7,970856	29,91882
27,92435	-0,44794	-3,15753	26,58853	8,075226	30,62827
28,0376	-0,15782	1,592194	28,57254	8,179535	29,39026
17,72363	4,020294	1,028656	29,0423	10,28552	29,00305
-16,9707	9,046661	0,141419	30,09357	13,29321	27,25824
-11,9424	8,756012	3,117065	29,70251	12,03378	28,08185
-11,966	8,807068	2,725037	27,75143	12,8353	28,94778
-12,121	10,92664	2,503235	22,99423	15,30789	28,45728
-10,1507	11,53848	-15,6261	3,716339	21,0473	25,495
-9,68313	12,84262	-24,2159	-13,84	23,47394	24,13849
-7,17488	13,04691	-20,7809	-12,161	23,19534	24,30627
-6,90344	14,03879	-18,733	-10,2999	22,18533	23,6069
-1,5145	13,59476	-16,0829	-6,76022	22,03201	23,66122
-1,01369	13,03235	-11,8867	-3,17891	18,68756	24,53937
0,596771	13,32071	-4,99928	-0,70875	-7,94584	26,52917
1,358032	14,7926	7,580811	3,455597	-8,60393	27,29251
2,467865	12,79889	14,79553	9,453308	-6,06286	31,54703
2,617981	11,88626	18,681	11,05957	-4,77115	36,70944
0,857819	10,37076	21,7406	15,12186	0,468231	41,47806
1,128021	10,65381	25,63361	19,93921	5,892487	42,77026
2,475952	10,99506	25,5741	22,0336	6,704651	19,43146
3,762268	11,60611	28,21597	22,92026	8,899872	-4,4209
4,326019	12,11823	28,68094	22,14212	9,936951	-1,01297
6,525604	12,93521	25,22974	20,49561	11,78131	3,94632
6,934723	11,95917	20,70871	21,54013	15,66782	5,331665
6,868591	6,739319	16,52533	21,45129	18,08194	7,916351
6,845062	4,295288	8,059723	27,35352	16,41302	10,33405

30,97504	-30,388
17,58105	-28,7652
2,605591	-28,0865
14,68179	-27,8546
16,50845	-23,9911
14,18842	-21,7495
14,42065	-20,0184
14,85446	-18,9836
14,44931	-19,9771
13,32733	-16,9995
16,03244	-15,9765
15,21097	-16,3441
19,08694	-15,9563
14,14069	
13,83789	
14,20093	
11,71924	
14,31158	
14,55338	
10,99829	
-6,49146	
-14,2035	
-17,7064	
-19,8396	
-21,4683	
-21,3778	
-16,6824	
3,708038	
13,53073	
2,024292	
2,96875	
-0,04962	
13,13705	
14,86853	
10,61349	
5,126801	
-19,7369	
-33,834	
-34,4368	
-32,3706	

Table A.11 Right wrist flexion/extension of S1 while playing to the rhythm game (first run)

2,980316	-26,6509	2,732849	-35,039	-16,5461	5,50647
2,995605	-25,6799	12,30823	-37,0468	19,32147	11,13
2,995605	-25,4214	18,18808	-35,4301	25,81223	3,173492
3,004089	-24,5475	18,43274	-34,8241	22,61755	-37,5327
3,004089	-16,0498	18,5282	-34,2534	23,12369	-25,4763
3,004089	0,648254	17,87274	-33,5611	23,89883	-20,1605
3,379211	2,019806	17,0629	-32,7484	23,52209	-20,2916
3,379211	-28,1409	14,56442	-28,6736	24,06912	-19,7786
3,614563	-46,5907	11,9288	-20,3407	-1,23253	-19,1505
3,614563	-47,801	10,41806	-18,3442	-45,6402	-17,7151
3,614563	-66,8789	10,21478	-17,7151	-35,6544	-15,3665
3,803894	-79,9871	9,995544	-16,3951	-25,9943	-14,2618
4,115051	-80,9058	9,697479	-12,1801	-25,0764	-13,286
4,638916	-79,4512	9,836517	-9,1616	-31,8309	-12,3186
5,618744	-79,659	9,216644	0,445984	-38,5672	-11,8395
5,620239	-78,0418	9,610443	7,703552	-44,2715	-11,3415
5,576447	-42,2603	8,77533	-34,0381	-44,4576	-6,30757
5,823456	-39,3466	9,265778	-71,1644	-38,9284	-22,1383
5,783478	-43,5175	8,973694	-55,3603	-26,0592	-46,4187
5,916199	-40,587	8,823853	-54,1975	-19,2835	-39,4358
5,165619	-42,8404	9,637085	-52,3082	-10,8534	-39,6361
4,785889	-40,468	9,7659	-50,6947	-8,96879	-38,7737
5,230011	-43,8794	9,592743	-50,4525	-6,90217	-37,4204
5,308105	-45,3585	10,20197	-50,5378	-6,81356	-24,0646
-4,31518	-46,2549	9,434631	-51,033	-6,07634	-10,0444
-69,0454	-45,9838	9,563538	-49,9921	-4,62173	3,438782
-62,4731	-36,2461	9,997833	-53,175	-3,03898	9,692596
-73,1273	-32,7953	16,79456	-38,4716	-0,52439	14,759
-55,4028	-33,7394	20,12482	-17,0347	0,39621	16,75027
-36,2246	-35,8565	23,2399	4,758209	0,188049	17,59995
-32,5327	-35,3711	0,39151	-23,6208	0,412079	17,83798
-30,4259	-31,0194	-40,7829	-63,0612	1,199829	18,16153
58,97745	-30,8117	-14,0312	-50,9292	2,035065	18,54044
60,68033	-44,1475	-32,3712	-55,9141	3,402252	19,60498
-44,6479	-24,6455	-30,2872	-56,633	3,668549	21,54446
-32,9945	-13,3073	-29,0117	-54,5096	3,84906	23,08667
-32,053	-11,2238	-29,9043	-53,5962	4,281097	23,6933
-30,9304	0	-31,4418	-52,245	5,252869	6,369507
-29,2437	0	-33,1738	-49,5961	5,04306	-19,1144
-34,6792	0	-33,9365	-48,0961	4,889008	-16,6196

-17,5096	-15,9148	-26,8529	14,48456	5,180389	-32,3758
-17,1296	-18,8906	-15,5548	17,37802	-28,1556	-29,3909
-12,5326	-16,9589	-15,7811	3,752899	-35,4324	-29,2866
-9,84899	-15,8435	-14,7561	-14,1182	-37,9153	-25,4383
-9,66643	-13,8776	-10,7185	-14,3775	-38,0693	-14,4228
-9,84648	-5,71564	-9,29647	-18,909	-32,0683	-4,07057
-9,86122	-3,47955	-6,80812	-18,6034	-29,0237	-0,55186
-8,76993	-3,21622	-1,1706	-13,0027	-14,7042	0,527985
-7,07747	-0,93937	6,726837	-9,44274	7,133362	2,517761
-6,18758	-0,19703	12,27545	-4,91194	20,40164	8,490417
-5,78992	0,60672	14,38635	-2,52088	24,98749	11,66141
-5,31467	0,810364	15,88593	-1,7711	25,71997	10,76849
-4,93081	1,206177	16,88861	-8,5877	26,70941	11,30875
-4,43531	2,447845	17,64261	-8,86088	27,39163	12,26016
-4,05644	13,24802	17,79938	-2,98028	27,59479	12,51001
0,01712	37,91782	17,92474	-0,05584	27,728	12,98413
14,43817	44,43896	17,90149	1,703339	27,10379	7,554626
29,20328	23,98434	18,0224	2,163452	24,77826	-15,607
33,30606	-10,9784	17,90112	2,682556	11,50839	-32,0972
20,04587	-16,6591	18,17133	4,333466	-28,1499	-32,8718
-20,9698	-13,5044	21,8501	9,096588	-29,3036	-32,5048
-22,1875	-12,4901	-14,1948	-2,07074	-26,2497	-31,7386
-19,5747	-11,1356	-28,991	-42,6427	-27,1484	-29,2248
-20,1043	-10,2316	-19,1978	-34,8603	-26,2695	-24,1476
-18,7847	-9,6548	-18,1466	-36,7707	-26,1011	-20,9818
-15,3044	-8,18958	-12,912	-38,7741	-25,7918	-18,5465
-9,02267	-6,07259	-4,65835	-38,3449	-25,5949	-8,19985
-7,03782	-4,05148	-2,40503	-36,9761	-20,1944	2,806976
-4,94298	-3,66455	-1,67711	-33,0402	-9,87799	7,542786
-1,7903	-3,23858	-0,52846	-24,5917	2,677521	8,833374
-0,31847	-2,7072	2,174469	-7,27653	9,041931	10,94696
0,754791	-2,4145	4,391815	3,267761	9,063293	22,29913
2,06311	-1,34728	6,645935	6,161713	8,461182	29,83942
3,99173	-0,64136	8,307312	6,925507	9,632355	22,46854
6,620148	0,413025	8,731354	7,198334	11,32996	-13,6625
14,03131	0,709992	9,748322	7,892242	12,66681	-33,7225
28,34528	7,619415	10,53696	9,069519	11,37289	-32,0127
33,61649	31,91129	11,22226	9,949768	7,218597	-31,2872
-3,34094	22,44656	11,34003	10,6557	5,450653	-26,8828
-18,2048	-39,6747	11,97662	10,13522	-22,5169	-24,5142

-24,601	6,222717	33,62	27,45947	16,01917	-9,42375
-8,2511	6,004639	36,90515	30,70941	16,08643	2,202301
15,15045	5,848663	36,7738	31,91159	15,38934	6,236664
23,76791	5,651886	35,82837	32,04758	15,12228	20,86655
22,8916	5,406982	36,06372	31,737	15,41306	36,62198
22,80011	5,120972	36,21609	30,18988	16,16318	38,11484
22,46332	4,973206	35,71646	28,81558	16,7363	35,57529
21,72131	4,691254	35,7345	28,14691	17,02231	35,3093
13,3721	4,385132	28,95175	27,60352	17,3324	34,40533
-6,55043	4,003754	25,1929	25,40515	17,40439	22,56686
-17,0549	3,82373	23,34152	21,99664	17,39264	11,28458
-25,1615	3,723511	21,40286	15,97217	17,37115	11,06232
-26,0254	4,133911	10,96655	12,9967	20,97815	-1,16715
-25,5946	4,011261	-27,5203	11,88257	28,89319	-29,3643
-25,213	3,921906	-25,5028	-12,1662	25,37112	-29,6705
-24,2921	3,739655	-20,9706	-22,4011	-11,5167	-17,7355
-15,7192	3,611053	-21,0132	-20,0209	-33,8685	-14,0781
-5,19847	2,993988	-7,06274	-16,6139	-24,9512	-6,08851
-0,53949	5,285095	1,417664	-10,7743	-27,145	-3,25299
0,928711	7,604858	9,509094	-0,80783	-17,0313	-3,47724
2,735626	8,111267	20,15985	8,491119	-7,24493	-2,63838
4,564636	8,566711	29,09515	18,33047	2,142212	0,316345
6,390076	13,13562	32,51056	24,55746	10,35077	2,055267
12,84048	21,53012	34,74927	26,64127	15,00922	3,511078
17,51163	23,42636	35,57843	26,75247	16,85226	4,027008
15,56891	19,5675	35,97318	26,91675	17,97632	4,378815
14,58606	15,17053	35,93195	27,44614	20,41565	4,683594
13,80713	-19,7541	34,13022	27,40298	21,76331	4,868988
11,66785	-44,5654	24,14862	24,76843	22,1257	4,979919
10,72385	-43,173	9,753784	19,6911	21,8273	5,084137
10,08801	-43,6494	2,554657	17,4715	21,79929	6,044434
9,021027	-43,9534	-10,3621	8,415924	22,02991	6,06604
8,003204	-45,1011	-33,5217	-8,3271	22,15646	6,23764
7,321869	-44,5875	-32,6008	-13,1778	25,39972	6,052673
7,006805	-35,0933	-22,4026	-13,7599	33,33728	6,380798
7,085419	-26,972	-11,7996	-5,08435	34,52008	8,602722
6,992828	-13,0526	-3,73931	0,546539	-16,705	7,974213
6,655945	4,978088	8,525574	4,138184	-29,4059	7,67511
6,472015	19,25476	21,12177	7,914795	-20,0229	7,713867
6,385895	27,5834	25,25851	11,73447	-18,5041	7,55127

8,033569	-24,6849
10,96313	-25,2802
9,679596	-25,4234
8,882874	-25,6104
8,633972	-25,7603
8,766449	-25,8212
8,434845	-25,7381
8,100769	-25,2734
8,860809	-24,4976
15,00992	-23,4616
16,02655	-23,485
5,419739	-23,0679
-33,0571	-22,9981
-29,9409	
-37,4352	
-30,3691	
-24,4443	
-15,7931	
-13,3071	
-12,8033	
-30,385	
-45,5155	
-43,2653	
-41,7517	
-39,9626	
-39,8546	
-45,9654	
-26,3328	
-23,2294	
-20,4956	
-20,4569	
-2,53704	
10,97125	
9,291199	
6,821533	
3,617554	
-8,3447	
-20,8308	
-24,288	
-24,3639	

Table A.12 Left wrist flexion/extension of S1 while playing to the rhythm game (first run)

Figure 5.23 – Second run

12,6413	-19,2986	25,95901	14,27609	11,90756	11,04169
12,6413	-18,3409	26,05487	15,64886	12,7485	11,13275
12,6413	-0,56	26,17792	17,08389	13,39178	11,51315
12,72696	8,169861	17,43188	16,80731	11,4675	11,71725
12,72696	14,31854	-25,2281	16,71838	8,917084	11,64212
12,78568	15,37317	-30,4048	15,69241	7,329681	11,6084
12,78568	20,45694	-26,5402	15,45248	6,798126	11,74048
12,78568	22,75134	-30,0234	15,21182	7,984955	11,84286
12,8255	22,57455	-24,9937	15,13855	10,40158	12,25571
12,8255	18,10721	-18,0961	15,79538	11,33844	12,44598
12,8255	15,97729	-15,7163	19,99023	11,87326	13,55011
12,88135	15,56558	-12,0894	35,10724	11,88458	15,40244
8,936493	16,70737	8,358704	16,98523	12,17615	17,65192
-5,25223	17,3479	-22,7078	-41,5478	12,37842	18,69223
-4,78693	17,55008	-30,9041	-11,7977	13,24118	19,3157
0,21521	17,75967	-29,4317	-10,9424	13,18512	20,21927
1,272736	17,91049	-30,6112	-11,0272	13,95547	19,34277
2,034576	18,47211	-28,0689	-5,20657	14,55713	-14,2819
3,754425	18,57745	-22,3028	-3,21571	15,78	-53,765
4,542877	18,89944	-15,4705	-1,67458	19,76123	-33,5923
4,972351	18,64624	-13,6735	-0,91399	23,17279	-42,1387
5,012573	18,91681	-13,5736	-1,01622	-7,32975	-18,2464
5,453125	19,36447	-7,11663	1,209412	-27,3019	-5,08176
5,849792	19,1832	-8,21107	3,017792	-15,6555	0,554077
6,583344	19,36115	-7,67409	8,217712	-7,99915	1,735352
7,248596	20,05011	-7,19197	9,352539	-1,65956	2,129486
9,056885	20,29599	-6,7286	10,25299	-1,09478	2,292542
-10,8773	20,16089	-6,01129	10,72729	-1,20967	2,652832
-49,7796	20,24677	-1,6143	10,7814	3,036072	3,378021
-46,1876	20,34705	-3,8609	11,22928	4,886749	3,692017
-49,3896	20,09802	-4,31478	11,64807	5,483063	3,478394
-50,8093	19,88577	-4,5405	9,436096	6,333801	3,538147
-40,6951	19,83954	-5,12967	7,74646	7,316925	3,813446
-41,0096	19,58948	-3,79875	10,67285	7,848907	5,625092
-35,5605	19,4917	4,171997	-5,53886	8,329407	11,37131
-31,4789	21,74188	13,26953	-31,7157	9,357391	15,07416
-22,4741	28,55215	18,39279	-10,3692	9,881256	16,31339
-22,5166	32,97186	20,19092	2,517273	10,0928	16,76096
-21,563	30,77267	18,14044	7,491211	10,4483	21,0972
-19,8924	26,98935	14,32382	9,250793	10,61111	25,68674

24,83667	-54,0351	27,87616	7,431458	0	0
-2,80657	-41,5926	28,2558	0	0	0
-30,3884	-23,4327	28,79837	0	0	0
-37,5117	-2,72745	29,4093	0	0	0
-17,6978	-0,8048	29,15054	0	0	0
4,320313	0,110413	26,1889	0	0	0
13,98679	1,70163	25,38873	0	0	0
18,66486	5,096588	21,13199	0	0	0
23,88126	11,58478	18,64117	0	0	0
34,37875	17,38	16,5618	0	0	0
38,53888	16,74811	16,57889	0	0	0
30,60031	14,80869	15,80435	0	0	0
7,741791	14,09076	15,57767	0	0	0
-7,96928	13,53448	15,20547	0	0	0
-5,20953	12,80414	14,88348	0	0	0
-4,5249	12,29083	14,70132	0	0	0
-1,11666	11,50433	14,92657	0	0	0
1,595459	10,63406	14,81567	0	0	0
1,155945	10,28824	14,76025	0	0	0
-0,2739	9,589447	15,47275	0	0	0
0,126282	9,856659	18,60529	0	0	0
2,345551	12,34186	21,8587	0	0	0
4,934662	15,89822	-2,96371	0	0	0
5,391449	14,99109	-14,1821	0	0	0
5,725372	14,73282	-15,9501	0	0	0
5,816833	15,24838	-7,75519	0	0	0
5,792725	15,96255	1,071167	0	0	0
6,193329	15,94122	14,47946	0	0	0
6,550446	16,00766	16,27292	0	0	0
6,903015	16,70413	14,37381	0	0	0
7,229034	16,55167	17,10278	0	0	0
7,537262	15,79034	16,40131	0	0	0
7,981049	14,30197	15,46823	0	0	0
8,40329	1,137177	19,89618	0	0	0
8,684052	-14,9158	17,90085	0	0	0
9,198822	-18,4015	-9,98069	0	0	0
9,46402	-17,0831	-11,8765	0	0	0
13,08749	-15,4926	-3,63211	0	0	0
17,78842	-0,34401	3,489075	0	0	-9,06764
-21,3327	20,91013	5,635376	0	0	15,59973

-9,95872	9,444092	0	-8,17855	11,65027	16,39792
0	-22,352	0	-1,30186	14,51035	8,512512
1,745514	8,830841	0	19,63586	20,53784	8,474457
10,7197	-8,57056	0	30,33786	24,27444	8,609772
0	0	0	16,2796	-23,3981	5,708496
0	12,31409	15,00745	-15,8589	-3,59922	0
-3,51761	0	-13,6251	-10,8121	2,324829	0
-4,68253	0	-10,3199	-7,90579	6,800018	0
-4,6156	0	0	-3,24224	13,34027	0
-5,10753	-10,0398	0	8,175415	18,452	0
-3,33228	-24,3069	0	11,09189	18,26385	0
-1,92409	-38,0165	0	9,545715	19,22495	0
-1,8408	-45,2794	9,38916	8,586639	18,50031	0
-2,88524	-48,8951	18,85934	8,821991	18,3577	0
-3,37873	-49,7612	19,69284	7,641998	17,48941	-27,2383
-3,33627	0	11,1124	7,869354	-19,5302	-38,5217
-4,02836	0	-3,17414	7,86554	-23,2447	-23,8928
-4,55314	0	-2,33	8,083801	-13,2016	-21,7715
-4,50717	0	-2,34609	8,530334	-9,46578	-18,6909
-2,05775	0	-2,35398	11,54294	-8,74631	-17,3215
20,14532	0	-2,52886	20,64728	-8,19003	-17,0422
39,42087	0	-2,49997	30,02023	-6,02395	-12,2519
24,20422	0	-1,89926	25,83817	1,802307	-6,99798
-37,7163	0	4,216431	20,01535	8,704285	-1,47052
-23,3435	-23,3346	13,6944	-11,13	15,75449	-31,1545
-21,3878	-11,6714	24,496	-4,39959	-10,7928	-32,4913
-18,7786	-11,7217	0,908295	-0,60002	-26,4638	-35,4982
-17,8737	-3,17487	-26,6264	1,872162	-23,9811	-28,2555
-17,0133	8,135254	-18,741	5,253174	-15,8163	-3,18332
-13,8403	15,10349	-16,1518	8,328918	6,703613	-43,2667
-11,2913	0	-12,9141	-6,58464	11,5072	0
-8,83901	0	-9,0432	-37,4452	-42,8961	-27,5142
-6,41185	0	-7,79061	-18,711	-26,876	-9,3579
-5,67995	0	-6,51424	-9,66581	-4,37947	-7,22395
-4,6979	0	-5,94409	-1,28322	2,540405	-61,5211
13,03946	0	-7,2254	3,68515	6,533417	-25,984
28,30673	0	-8,2562	6,137634	16,38412	-12,153
0	0	-8,91019	7,258636	15,07251	5,929169
-9,19427	0	-8,38609	9,322296	17,4223	-8,66748
9,411499	0	-7,85817	9,800262	20,43982	0

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-21,6764	0
-20,5141	0
-22,8521	0
-23,2321	0
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Table A.13 Right wrist flexion/extension of S1 while playing to the rhythm game (second run)

16,55884	-8,1781	2,198578	15,85797	20,08466	15,37238
16,55884	-1,17093	1,944824	16,76559	17,22675	20,12827
16,55884	12,31995	1,917236	18,25632	16,30811	10,03558
16,63916	17,4838	1,97818	27,492	14,87766	-8,97148
16,63916	23,85669	2,454651	-10,3736	14,73004	-10,0035
16,82053	26,40509	2,757294	0,505158	14,99799	-8,08625
16,82053	28,62152	2,559723	3,483307	19,62375	-2,44102
16,82053	28,02423	2,284485	12,69806	22,30444	0,114594
17,00235	25,48611	2,609314	14,51144	-14,1564	5,955353
17,00235	21,23959	4,257355	15,10068	-13,5752	10,39392
17,00235	19,14111	6,8302	14,51941	-10,6287	13,96866
17,63705	17,96115	6,734467	14,24124	-7,1752	16,53552
18,06821	16,61749	7,244415	14,90323	-1,64434	19,46548
15,75311	18,86453	6,598724	14,59335	3,7276	18,59479
13,86389	20,34866	6,060974	14,1507	8,247223	18,61792
13,85266	25,45471	5,376801	13,70029	9,66507	18,62756
15,11874	24,81186	5,327362	13,80042	10,36301	18,39365
7,413361	-0,39521	5,471985	14,25558	10,98376	18,31354
-21,23	2,236389	9,832672	14,44705	10,492	19,23309
-26,6617	3,098419	17,04132	14,95746	10,35034	19,37384
-24,8946	4,394684	16,9588	16,24554	10,79172	18,67508
-24,1965	6,092621	13,39035	22,70319	9,326874	19,45453
-22,9373	7,748566	14,51596	32,79712	9,373901	19,76248
-19,1684	9,727509	-1,48465	33,73007	9,608093	20,68417
-19,3243	11,18912	-14,4951	2,518005	10,90933	23,49719
-19,2923	13,06686	-14,7939	-5,02338	19,30969	27,00467
-18,5696	13,3978	-14,53	-3,2576	32,27115	37,0257
-17,0364	6,922241	-9,66148	-2,64033	32,31467	24,98248
-15,7927	-15,2224	4,556152	-0,29341	27,71991	-11,8646
-15,8107	-14,9801	18,44327	0,107605	25,35043	-5,9477
-15,4638	-8,08544	21,6947	0,8862	23,35178	0,427826
-16,5817	-2,36154	27,39084	5,854034	22,13263	11,32526
-16,2427	2,116852	40,73373	15,11832	22,14639	20,46869
-15,1882	2,456848	42,18863	15,28146	23,58798	21,15762
-16,3781	2,447693	38,35657	-6,83846	21,37366	20,53909
-19,0841	2,558289	36,20416	-27,7113	3,745636	20,54538
-20,0676	2,460907	29,01041	-5,58902	-15,0213	21,07251
-17,9398	2,321472	24,92374	12,60132	-14,1164	20,88751
-15,2359	2,233002	19,75845	25,04694	-9,95506	-6,64664
-9,88218	2,161957	16,91229	23,82605	-3,45851	-14,5999

-0,49217	18,44485	27,06989	6,100677	2,085846	-13,1267
15,27573	18,10928	27,83286	12,20343	21,47473	-8,24365
39,47009	17,99435	29,54907	-7,62803	-1,48816	-8,66771
45,06229	18,13867	37,16095	-50,2077	-69,7895	-9,15772
40,83432	18,05972	38,8616	-20,2248	-59,7473	-2,68569
29,20154	21,55759	35,82129	-6,78895	-13,3487	2,426453
21,79605	25,80457	38,49402	15,90439	-13,8224	8,616333
23,48404	26,60599	38,75482	22,17407	-19,3029	18,60849
13,65683	26,56143	37,12109	6,025238	-22,2353	4,243988
-7,4463	25,91226	34,54318	-26,1939	-27,5525	-63,7672
-13,948	21,85849	16,97632	-56,0689	-32,2705	-44,0652
-12,5366	19,24774	-7,11885	-71,5645	-27,3545	-38,2618
12,74625	18,24844	-8,14788	-73,1599	-26,2128	-34,7986
31,98016	21,77631	-7,68982	-68,0672	-27,3225	-21,9555
33,01984	15,57706	-3,25312	24,85168	-26,7741	-14,9491
33,44769	-23,3674	10,23499	55,32242	-27,3906	-13,7568
32,96848	-15,5032	16,66498	57,83099	-27,5725	-13,3701
30,15146	-11,0172	20,6113	46,4173	-25,6952	-14,2599
28,89563	2,712799	19,65771	40,82574	-19,7182	-14,2142
27,9534	10,79254	19,07419	34,60229	-10,7944	-14,2031
26,85834	15,76608	18,36142	26,48334	7,893188	-14,1444
25,42447	17,98203	17,80161	25,08032	27,85889	-14,947
23,93207	20,25748	17,6015	22,67529	-48,2969	-15,1279
18,25696	21,22214	17,2778	19,06226	-38,8253	-15,3983
-4,32411	22,63904	17,50278	17,93826	-33,3997	-16,0794
-7,35987	23,81229	17,03311	17,41907	-58,8473	-15,6175
-1,59632	24,27313	17,82526	15,95288	-38,1553	-15,5865
5,422852	24,36176	19,11426	14,31155	-29,6775	-16,9396
7,944122	24,68774	19,87604	11,6221	-21,4211	-16,0684
10,91647	24,84634	20,20798	7,081238	-27,4372	-15,4421
17,91739	24,98898	20,10696	5,039246	-25,0936	-16,1637
12,70535	25,22272	19,43665	-0,6789	-20,6848	-16,1851
3,901672	25,3768	18,47995	-2,64847	-20,8642	-15,0548
8,729156	25,29333	14,61819	-3,84667	-15,3314	-15,511
15,914	25,7832	4,310242	-4,74083	-17,8547	-15,5715
18,2406	25,97046	-17,0677	-5,41729	-15,8565	-10,5713
19,35056	25,98013	-11,8143	-5,9052	-15,358	-9,83367
18,94559	26,13742	0,442017	-6,04654	-15,1605	-11,5243
19,43381	26,53143	11,24557	-5,17777	-15,8341	-12,4798
18,746	26,58542	7,131287	-3,4213	-16,2266	-12,563

-12,1209	13,5043	0,858734	-18,8729	-24,8544	-43,5468
-12,0388	13,34784	0,618042	-16,4721	-11,1706	-30,0719
-13,28	13,52469	5,660797	-9,97189	0,871094	-29,5625
-12,4488	12,72656	16,61884	-6,31254	4,725739	-25,2973
-15,1703	9,831726	31,99246	-3,83143	3,503265	-7,65088
-12,3256	9,437866	0	-3,49092	0,962952	-7,79836
-15,1483	9,306122	0	-2,10823	0,448364	-18,2374
-12,403	9,511292	0	-1,08704	-0,4387	-20,4494
-9,73347	7,109802	0	-0,15219	-1,06096	-8,11299
-1,45959	-3,25463	0	1,04071	-1,04461	0
6,825897	-24,9137	0	2,153046	-0,97392	0
16,36475	-43,3524	0	2,407166	-0,82484	0
10,8392	-41,3488	0	8,898865	-0,60738	0
-62,1854	-39,3893	0	11,72418	-0,40713	0
-60,7692	-40,4167	0	-26,5327	1,034912	0
-26,9281	0	0	-23,7558	7,595856	3,073975
-27,0619	0	0	-10,5516	9,148895	-45,7382
-19,4332	0	-10,115	-8,05615	-28,7684	-45,2101
-9,502	0	-6,29143	0,804688	-39,9801	-40,0473
-5,85846	0	-9,24322	5,264038	-42,1617	-27,4356
-16,5807	0	-10,9503	6,098907	-38,0971	-23,1237
-26,916	0	-12,8325	8,335724	-37,6411	-21,4769
-20,8124	0	-14,0784	13,07706	-34,6625	-19,4887
-18,4436	0	-13,1063	16,21231	-29,4274	-15,9642
-20,186	0	-11,3179	18,28329	-18,1195	-12,4409
-20,6817	0	-10,8837	17,84241	-10,5638	-15,5585
-18,2246	0	-10,1395	16,86673	-10,4382	-17,3161
-17,7085	0	-10,1031	16,77734	-13,1743	-18,8121
-7,17848	0	-10,1809	16,53381	-14,6291	-18,6432
8,806763	0	-10,5903	16,71527	-19,4558	-18,6648
20,24182	0	-11,0774	16,66376	-19,3007	-20,2765
21,34296	0	-10,548	16,40656	-17,2885	-21,164
22,14871	0	-6,30617	16,54254	-17,4667	-22,1537
24,19855	0	7,275085	13,5097	-18,5308	-21,7893
26,32025	-18,0981	20,78787	12,785	-18,6015	-23,1951
21,69861	-12,2617	0,015442	15,07123	-17,8489	-24,5597
8,232147	-8,11649	-31,8674	12,30225	-15,7169	-25,0774
12,14178	4,883148	-23,3521	-32,9724	-6,2935	-25,4527
13,42285	2,122742	-28,3547	-17,3347	6,005127	-24,0672
14,50491	1,163086	-21,7002	-31,3756	-3,19489	-22,9158

2,092407	-33,5921
1,497375	-6,19124
-37,7201	0
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-22,3837	0
-18,8721	0
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-16,7291	0
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-25,4837	
-25,6793	
-26,6329	
-30,5502	
-24,0693	
-27,3172	
-25,908	
-26,083	
-31,156	

Table A.14 Left wrist flexion/extension of S1 while playing to the rhythm game (second run)

Figure 5.27

22,52963	-21,0156	-2,76886	40,96091	-9,23666	-29,9669
22,52963	-14,9062	-11,0152	40,90143	7,129982	-3,27063
22,52963	-3,43268	-9,00931	41,30394	21,31276	8,119175
20,59984	-0,82156	-5,90991	40,66123	25,04147	16,87499
20,59984	-2,44571	-6,93716	39,7066	29,2399	17,26854
20,59984	-5,88422	-15,1697	39,51368	32,06701	9,682076
-7,34183	-18,9888	-42,1088	38,51927	33,77921	7,958671
-15,4079	-20,7741	-56,688	13,68115	16,54588	-3,95566
-20,6003	-20,3701	-57,2088	-0,01077	24,7402	-12,0293
-21,1643	-19,3061	-56,745	-8,39743	26,37092	-9,89999
-9,50201	-18,6488	-55,4996	-9,81122	30,57841	-8,3638
-1,27567	-18,5934	-54,8743	-19,5697	35,69255	-8,58868
3,894851	-18,4466	-52,71	-25,6999	35,89619	-2,793
6,144424	-17,2393	-53,1748	-27,8901	34,16197	11,63094
2,455631	-8,448	-42,8623	-27,7588	32,61749	22,01189
1,506652	5,540336	-22,1515	-13,8271	30,79086	26,75189
-2,94974	9,381708	-13,4576	0,212633	38,72481	29,95774
-4,18176	11,14654	-6,99329	-0,04205	41,18034	30,67429
0,254883	11,37608	-2,75006	0,728901	40,79784	29,18267
5,413794	12,06382	-7,23395	-16,8204	35,28815	31,51452
4,120808	12,37212	-8,50012	-34,5083	33,93398	40,81438
1,440873	12,04527	-9,85022	-42,1625	30,88935	42,31055
-0,20432	13,52025	-23,7785	-43,2266	-0,16769	40,11917
-0,84753	6,166866	-21,5443	-43,2845	-17,4607	37,53455
-0,63364	15,48962	-19,7376	-42,1378	-21,6537	22,58905
-0,49899	23,2423	-16,9321	-39,1937	-22,0491	18,6064
-0,55942	27,03465	-3,65131	-36,8925	-24,5505	19,91212
-0,68738	28,26749	21,62376	-27,6839	-25,3781	28,74447
-0,59021	27,5456	32,01062	-18,2387	-22,9446	32,08997
-0,60745	30,44159	35,46787	-2,86279	-21,983	32,99846
-1,44223	39,47816	35,8216	2,57543	-21,8423	31,6327
-15,2991	41,56655	35,75436	2,747219	-21,8657	31,14946
-23,9083	41,03792	33,89074	-2,16541	-22,904	22,69218
-24,0405	26,8033	34,69952	-7,84106	-33,5421	-2,66208
-24,433	13,76383	32,40949	-9,52368	-35,0756	-14,7602
-24,3251	-2,45013	26,73843	-21,4725	-34,847	-16,1038
-23,8406	-1,32419	24,9917	-18,6725	-34,8116	-17,5062
-20,8503	-0,34375	28,02285	-17,5	-35,0952	-17,6401
-21,3945	0,583599	38,46379	-11,5288	-34,4982	-16,6056
-21,2531	-0,17465	40,34428	-9,69925	-33,2167	3,913665

8,497171	26,77269	20,31102	-20,6386	-10,7671	9,292816	-19,2127
6,249576	26,46937	23,80276	-8,64825	-24,3551	8,027063	-18,225
-1,98132	26,0366	26,71944	9,214785	-28,6834	8,07977	-17,4789
-16,5557	25,6911	33,49865	12,7812	-29,8507	8,713861	-14,8769
-16,9122	24,97853	36,77261	12,07771	-28,9105	9,901237	-14,0905
-10,1129	24,37569	37,86907	10,58956	-27,1503	9,8593	-10,7338
-10,4034	22,82194	38,89548	9,172656	-26,9784	8,58605	
-9,42175	-21,5717	38,17213	6,43882	-27,0246	-5,62006	
-9,59415	-21,3716	36,9002	3,465088	-19,5406	-11,7126	
-17,222	-24,1516	37,22238	3,884912	-17,1451	-20,7393	
-24,6711	-30,384	37,00308	7,167261	-16,9703	-21,0764	
-27,2652	-31,582	33,72277	9,524709	-17,105	-19,4008	
-26,7169	-31,5072	18,22922	9,254614	-18,7804	-20,5578	
-24,4558	-26,9832	6,123719	7,12535	-19,1702	-18,4607	
-22,7293	-5,61472	-5,19025	9,552551	-22,4693	-15,6379	
-5,98383	-1,11942	-5,52744	24,14684	-22,2331	-15,8	
11,43619	-2,08487	14,52708	28,52751	-17,7963	-23,764	
19,29647	-3,9324	20,75271	38,48406	-1,80527	-24,6427	
21,85927	-13,4767	21,4682	44,82079	11,57894	-25,87	
20,91727	-27,7931	20,20957	46,58891	23,72086	-24,5162	
16,78677	-30,3337	3,216715	46,05682	25,16744	-23,5172	
3,137711	-30,0028	-16,8126	41,71232	25,53448	-22,5872	
-2,17282	-29,8272	-22,3258	40,0437	25,70617	-16,6787	
-2,93561	-29,3011	-21,7054	38,79142	24,30852	-17,2497	
-1,54291	-30,4893	-21,7917	34,12196	22,64473	-17,5251	
-0,79791	-31,1123	-22,1516	21,706	22,56839	-18,1858	
3,000121	-31,5501	-21,8236	11,94324	22,37479	-18,2682	
18,03413	-31,7996	-9,06027	13,01268	22,92916	-18,268	
27,03101	-29,1338	-7,25745	14,40745	25,82995	-18,3897	
34,06345	-7,8681	-9,46811	20,03221	27,44604	-18,4189	
36,18073	-1,36969	-9,94162	19,71163	26,59945	-18,0646	
36,96129	-0,27853	-13,9036	17,74267	26,2508	-17,4113	
36,81891	-0,83783	-11,8581	17,62654	32,79186	-16,2956	
35,85466	8,038464	-12,3074	17,82378	41,48738	-14,1404	
32,80079	8,795421	-20,7822	8,120931	39,56995	-11,4132	
30,82794	4,355391	-22,3374	-6,17072	36,56056	-11,6915	
26,20261	2,601348	-22,9869	-8,37567	35,07869	-11,0714	
25,98672	2,644941	-22,6183	-9,02911	32,18069	-8,41864	
25,92682	4,577055	-22,5024	-9,94254	30,75041	-3,08524	
26,02452	11,45079	-23,2559	-10,712	15,06468	-19,8458	

Table A.15 Wrist radial/ulnar deviation of S1 while playing to the deviation mode of the ski game

Figure 5.28

12,13882	-10,3288	1,789814	42,12817	8,874481	-16,7757
12,13882	-10,6505	2,565936	42,30551	25,85068	-25,6247
12,13882	-16,4049	2,210216	40,38891	38,62919	-39,8327
3,887265	-17,4271	-8,62372	41,11534	44,55665	-44,9988
3,887265	-15,9785	-13,8896	40,14687	44,46132	-45,933
3,887265	-14,3977	-12,5906	24,07419	43,47509	-42,884
6,30889	-13,3744	-19,2575	-5,8844	42,06454	-28,329
-0,57944	-13,1826	-19,6563	-3,41531	41,59891	36,16404
32,61679	-13,9113	-22,4956	-6,25571	41,38806	36,97874
38,11279	-13,6723	-21,752	-7,19678	41,18381	31,02626
39,83035	-2,76035	-22,2465	-7,34247	42,58682	27,4392
39,85399	42,14621	-22,1206	2,55898	41,12854	25,1341
39,87848	44,95361	-22,4236	-0,59988	41,81559	23,58839
39,9436	39,29059	-22,0304	-12,9327	40,90448	21,74023
39,27851	35,26772	-12,2301	-16,2406	38,6771	19,18552
40,17969	32,09126	14,35256	-14,3666	38,09727	17,85073
40,9701	30,89209	12,86741	-12,2893	37,65432	17,29083
25,53812	22,41324	2,675549	-12,6238	38,69164	32,88203
-29,548	26,44348	-10,7094	-11,9558	38,55692	36,52305
-25,6383	31,49633	-15,4033	-12,7044	38,17827	37,08011
-25,1001	39,09948	-21,0667	-20,3483	35,27999	36,78725
-23,3611	37,91735	-15,9536	-21,9232	34,91187	35,66385
-5,89697	34,11722	-14,9762	-18,6629	24,0977	34,9249
-4,79865	34,3326	-14,0663	-19,3736	6,491111	34,87117
21,61308	37,75745	-10,9523	-18,2516	1,58657	35,08789
30,02393	42,66188	3,957799	-19,3977	-2,38895	33,78588
29,77461	43,958	25,60943	-15,1463	-4,7522	33,36473
20,14152	40,40746	23,53071	-10,737	-6,05362	32,50997
-5,31934	40,40577	19,13377	-38,3444	-21,4517	33,89349
-11,6069	38,71588	20,62144	-42,1852	-23,0999	35,26165
-11,5008	44,14429	25,31614	-46,2657	-19,7268	36,08147
-13,8394	45,02034	25,62868	-46,6907	-21,6229	35,90296
-10,2671	43,9137	29,99203	-5,0441	-20,9891	33,74881
-7,79639	42,21734	36,67401	11,71468	-21,0027	18,63407
-7,64865	33,58753	39,17356	6,715204	-18,8076	10,94421
-32,3793	-1,47437	37,5393	1,469591	-13,0614	-3,25873
-28,8691	-4,50772	36,59058	-5,30515	-15,9927	-11,088
-19,8951	-4,79074	37,54205	-8,51413	-17,4725	-18,4665
-16,6668	-3,39227	39,23045	-9,06705	-18,3341	-18,3717
-11,8453	-1,98221	41,84634	-5,22965	-17,9525	-18,392

-17,8789	20,73578	18,80127	-21,2401	-46,1717	7,472719	12,23456
-17,1543	31,71996	37,77922	-4,00107	-46,8938	10,27319	1,477802
-17,3631	37,74795	40,20757	19,50965	-47,2188	11,36726	-6,11276
-17,1579	37,35757	40,01828	27,70914	-46,0933	12,53077	-6,81476
-16,9983	33,85789	39,45291	22,0836	-46,3537	12,78019	-6,44629
-21,4754	31,84808	39,4026	17,66912	-47,0784	12,70885	4,670191
-28,9251	32,15761	40,74368	12,7716	-48,0092	12,42259	
-28,0979	21,61679	43,73706	12,06575	-14,4887	9,191808	
-25,7827	14,6719	42,12321	11,94271	-15,6326	-17,6496	
-23,4808	-9,85138	39,2087	11,27352	-23,708	-10,5797	
-23,2524	-7,96591	36,73023	10,84271	-24,7884	-9,44962	
-27,7505	-8,87726	36,16545	11,30996	-27,8286	-8,9881	
-25,5873	-8,57163	36,93311	21,76289	-27,039	-7,87503	
-21,1594	-6,96344	31,45151	42,34356	-22,088	-30,3444	
-18,8676	-6,10184	2,413556	49,56116	-16,2785	-43,4478	
-12,2012	-13,3708	6,548829	53,53391	-16,0989	-46,8758	
-3,32599	-18,1622	8,811597	58,0987	-19,0683	-47,6559	
2,458996	-12,3214	23,85067	56,86371	-14,3753	-44,9383	
-0,29605	-12,7594	33,7053	56,154	16,86901	-42,4951	
-3,49616	-12,6326	28,05147	54,99377	33,24004	-39,784	
-9,4032	-16,0513	22,27784	52,88154	35,36909	-4,54587	
-10,7334	-21,8627	1,289375	51,56253	33,7827	27,9515	
-7,71451	-24,351	-20,8024	46,86297	31,03471	11,49424	
-4,08112	-30,2405	-19,6953	20,32747	29,88415	-0,27362	
-1,52261	-31,1464	-19,5886	2,930603	30,96131	-6,05911	
0,076618	-28,5365	-18,0383	6,370977	30,83621	-26,2899	
4,428014	-30,9001	-17,4068	8,379272	30,0847	-42,0286	
18,50886	-33,9103	-11,5681	10,31853	32,71133	-55,7235	
26,02698	-33,2809	-8,32608	18,64102	32,32971	-64,6913	
31,96836	-35,0015	-7,78766	16,13924	33,67498	-54,7657	
32,64555	45,01721	-4,90057	14,2456	40,2746	-24,4115	
34,41202	59,57175	-13,538	13,74576	44,41958	-11,4943	
34,79439	82,70889	-14,7483	12,66733	46,27151	-8,63031	
32,72718	9,133484	-19,0016	11,84788	46,72532	2,982114	
37,22202	8,713661	-18,64	-2,22971	46,1962	5,878504	
25,90706	17,99966	-15,4483	-39,531	47,99893	7,579046	
24,78742	17,97499	-17,0171	-45,8714	45,1727	10,59655	
6,0997	18,84443	-18,8141	-49,0133	40,51762	11,7327	
27,87376	17,38974	-19,8895	-49,1465	4,772298	12,56751	
13,54654	15,5359	-19,1869	-47,9431	3,828034	11,86786	

Table A.16 Wrist extension/flexion of S1 while playing to the extension/flexion mode of the ski game

A.2 Fourth experimental session

Figure 5.29

-50,21219	8,015961	13,16492	7,951691
-50,21219	-0,20189	12,31726	-15,02361
-50,21219	-0,6522246	0,8990173	-29,87887
-50,47149	-5,634959	-8,821561	-41,04795
-50,47149	-13,06563	-5,964678	-47,61058
-50,47149	-15,10778	-4,552179	-49,83379
-50,66008	-14,3302	-4,575128	-54,14643
-50,76807	-10,02339	-3,916547	-51,76284
-50,76807	-0,3590909	-3,558567	-51,65334
-50,82243	9,467255	-3,065753	-52,09915
-50,82243	10,34821	-1,788199	-50,71306
-51,12931	11,48972	-0,8680527	-49,82272
-50,5199	13,01843	0,01907349	-47,86803
-50,84466	14,83499	2,895599	-47,25843
-44,49619	15,12177	9,111847	-50,72193
-36,03614	14,7142	13,48236	-57,31407
-22,09856	14,04776	14,49438	
-16,43248	12,46133	14,72665	
-9,458612	10,07458	14,74393	
-3,202045	8,973419	14,67404	
-1,803558	8,586029	16,68008	
-3,544054	8,366821	30,54108	
-5,229431	8,490875	54,88937	
-6,796763	8,531555	68,914	
-8,67713	8,042358	69,24542	
-10,17648	7,800201	64,45395	
-1,905756	7,500641	67,25507	
5,036835	7,324707	68,5347	
9,775513	7,078278	68,4765	
12,73596	6,057831	70,67236	
19,44604	5,535187	70,84537	
25,33743	5,084045	72,53568	
24,25012	4,984589	72,4693	
22,34799	4,428467	72,46033	
21,74734	4,217072	73,56177	
21,80701	6,40271	72,97427	
21,92651	13,96695	72,22772	
21,93863	14,07059	62,21704	
21,59216	14,38364	51,25531	
19,27264	14,05862	36,75076	

Table A.17 Wrist extension/flexion of S1 while playing to the Flappy Bird-like game (first run)

-21,6121	-8,44084	20,23096	-27,6728	-3,23666	25,37842	21,97858	-19,1707
-21,6121	-6,78287	19,35934	-28,9341	-3,15746	7,829041	20,75305	-17,9828
-21,6121	-6,94421	18,33301	-26,9066	-1,98523	15,90866	19,71866	-16,7861
-20,7322	-7,14201	17,66379	-26,0777	4,369904	23,99036	13,85641	-15,3374
-20,7322	-8,28674	17,24988	-25,6783	11,42584	26,17755	8,878967	-14,0047
-20,7322	-8,46195	18,07758	-26,0313	15,81842	26,80688	7,389313	-12,7985
-19,0199	-9,42573	20,64938	-24,4785	16,72168	26,64038	7,562195	-7,21272
-19,0199	-9,55181	21,36874	-17,6922	16,86041	26,38715	7,63089	-1,09878
-19,0199	-8,83178	21,24261	-2,97426	14,50266	26,71301	7,324738	12,19141
-18,1944	-5,84787	20,77347	1,562195	8,454926	26,59131	3,866882	23,13348
-17,4077	-3,92828	18,98029	3,381317	3,776367	25,70383	-7,84438	28,35886
-13,4569	-3,61544	18,63098	5,201416	0,160095	23,80637	-15,2241	29,83975
-6,58703	-4,30017	18,32117	8,615082	0,822601	17,86926	-16,2893	30,51157
-3,97144	-4,37556	17,91165	11,38397	14,04233	6,951569	-15,8336	30,76306
-2,33844	-4,55189	17,3295	11,36908	28,66895	10,04807	-14,2256	30,81174
-1,56366	-4,81126	16,7666	10,91895	35,7619	12,72101	-8,51892	34,15167
3,306671	-5,21042	13,79254	6,825623	41,79114	14,95276	-7,21645	42,2597
10,43307	-5,59419	15,11597	1,636444	41,73721	17,29608	-6,68998	55,93661
14,22885	-6,0026	26,58142	1,654327	41,16498	20,21765	10,08682	65,12134
12,5412	-6,60407	44,26633	1,559235	40,9931	18,70255	28,94116	66,29187
11,05344	-7,17377	47,6225	1,233673	40,24445	4,866974	33,49881	62,58817
9,580017	-7,39149	48,73697	0,95755	41,87299	-2,93987	36,9375	61,45169
8,48233	-7,54117	49,13043	0,566498	42,32092	-5,96467	35,09766	63,79758
7,46283	-7,651	47,57672	-0,06146	40,51898	-7,58988	33,03983	57,46121
6,064362	-7,81606	42,95282	-1,52808	42,2825	-9,90389	31,24918	-72,6038
4,674408	-7,9594	41,2572	-2,02078	45,40402	-11,7301	29,8317	-80,5526
4,038544	-8,07633	40,86639	-2,25852	52,31433	-4,58062	28,04178	-81,7771
3,279236	-8,26769	39,95706	-2,88751	50,64407	8,974457	27,32623	-81,9029
1,546783	-8,46646	39,39349	0,772308	44,11215	9,374298	27,00613	-80,9908
-0,48627	-8,80858	38,8454	12,14261	39,68161	9,18103	26,50449	-67,345
-2,50524	-9,31239	30,02029	12,70093	39,25714	8,232727	25,42731	40,31247
-6,25535	-10,9863	-2,72908	12,58997	39,08191	13,63205	24,38739	
-8,05415	-13,8482	-25,1144	12,79556	38,9975	30,9429	18,19208	
-11,4749	-15,5081	-29,7338	12,60931	36,82419	34,4899	6,497406	
-12,6932	-14,3152	-28,1092	12,05698	25,73254	33,39032	-4,74017	
-12,9384	-1,54506	-26,6919	11,25986	24,80591	30,12808	-8,5502	
-13,4829	4,648254	-25,9205	9,768433	25,29181	27,414	-19,593	
-12,4962	15,8761	-26,0029	8,652802	25,96976	25,505	-24,4831	
-9,97008	19,86136	-24,3207	2,224304	26,47165	24,94702	-22,1619	
-8,88055	20,18628	-26,0688	-2,73733	28,64102	23,89282	-20,1693	

Table A.18 Wrist extension/flexion of S1 while playing to the Flappy Bird-like game (second run)

Figure 5.30 – First run

8,976471	-40,5327	-42,4457	5,291321	14,29074	-20,3569
8,976593	-36,4616	-44,705	1,74649	11,4248	-12,8253
8,976593	-35,9881	-41,7543	16,68832	-31,0308	-3,18985
8,977081	-35,0769	-41,8497	15,54092	-58,7029	4,382324
8,977081	-34,4304	-42,6203	10,74139	-45,432	4,03421
8,968475	-33,7434	-43,8719	8,801788	-43,944	3,619659
8,968475	-34,4009	-42,1542	7,334229	-40,0721	3,423218
8,968475	-35,0679	-41,8397	6,837799	-38,2767	3,438812
8,963593	-35,7224	-42,8331	6,259399	-36,4065	2,462402
8,964172	-36,8371	-41,7125	9,170288	-35,8563	7,174072
8,964172	-36,9919	-40,6717	-15,6523	-35,5776	10,52798
8,940735	-37,1065	-27,8105	-55,8002	-35,2552	9,881042
8,829193	-37,167	2,14975	-45,0239	-34,9181	10,81302
8,743195	-31,6553	21,2662	-43,9027	-33,7919	9,395294
8,750763	-14,1526	-22,8729	-40,0474	-32,0904	7,834625
7,059021	8,441925	-61,16	-37,7085	-30,875	7,592529
-16,3492	25,78317	-46,7642	-35,1894	-29,664	7,5784
-42,6201	36,99307	-54,6103	-34,2865	-27,5433	7,018463
-51,8062	45,28421	-53,7866	-33,3714	-21,3267	6,847076
-53,5165	46,9888	-56,0226	-32,8142	-4,11737	6,4953
-54,9923	29,89664	-58,5567	-30,4789	20,87726	6,328552
-53,7008	-24,8196	-60,0768	-7,23442	28,672	6,817993
-52,0212	-58,4766	-61,9671	13,97656	26,68329	6,845337
-51,0749	-51,2518	-63,2178	16,79489	25,40787	7,366119
-50,6111	-46,4869	-58,7089	15,57382	24,30499	7,836548
-50,8077	-44,8152	-53,9245	14,73987	19,38742	8,485687
-51,2283	-42,4962	-52,9755	13,82065	-27,024	8,375885
-51,6357	-41,3995	-52,2006	13,28348	-32,5198	8,682709
-51,5093	-40,101	-50,0399	12,97888	-30,9335	8,954468
-51,4068	-39,3177	-49,2836	12,59808	-31,2619	9,113983
-49,2185	-38,2629	-48,4203	12,56683	-31,336	9,177643
-38,4254	-36,8592	-48,0656	12,37527	-31,1411	9,262909
-21,5306	-36,4326	-47,6371	11,41519	-29,5195	9,459991
-1,921	-35,4784	-47,9277	19,78925	-28,1534	9,39151
11,80649	-33,432	-46,0197	17,526	-27,3634	9,361206
26,05441	-42,1752	-37,2189	16,24048	-26,8584	9,308777
37,60205	-41,7029	-35,1988	15,08893	-25,7429	9,089081
-12,2278	-42,9555	-46,5834	14,39099	-24,7471	8,939514
-39,7486	-43,0109	-25,7867	13,47812	-23,4584	8,630035
-37,7655	-43,8913	12,10574	13,18015	-22,0112	8,398682

8,135345	3,187347	11,25504	2,295319	27,9241	-19,9428
8,111359	3,852478	11,267	3,891815	27,45703	-16,6018
8,110565	4,648224	11,31055	10,33011	27,90091	-14,1651
8,05304	4,830261	11,60837	15,23288	26,95615	-6,85403
7,973114	5,788116	12,32178	14,26682	26,58124	5,206482
7,976288	12,80545	4,878937	-12,5018	26,40668	13,21979
8,06427	20,75449	3,717224	-39,1442	25,68307	5,726013
15,64603	26,64578	18,40662	-38,1944	20,84213	-25,6235
-0,72124	4,294556	18,27594	-35,9308	19,52774	-33,5782
-39,4324	-16,9827	17,71469	-28,7219	14,43805	-32,5301
-37,5611	-13,3588	0,955872	-20,2832	-17,6558	-29,3761
-31,6961	-12,99	-34,617	-11,5719	-31,0452	-21,7396
-25,5955	-11,8488	-27,6629	-2,28884	-31,0499	-15,0593
-13,6087	-9,48533	-29,2474	4,421539	-30,6932	-10,2256
-1,12002	-2,47641	-29,3126	8,353485	-27,3124	-3,20515
8,787872	1,271912	-24,5183	11,34006	-23,9858	0,600769
12,68512	1,182465	-18,2532	12,24936	-8,94594	2,431641
13,63858	1,022095	-14,1688	12,8504	10,74408	4,360718
14,92508	1,03363	-12,0726	13,26898	24,34662	4,955505
15,57846	3,067261	-10,0407	14,00992	26,62485	9,491089
16,05035	5,595276	-8,23986	14,91492	27,83722	8,618591
16,20306	4,537445	-7,0042	15,67801	28,61908	9,93808
16,75659	4,728821	-5,22694	16,93176	29,23361	9,329926
17,0267	5,478027	-4,16174	18,72681	30,02606	9,825714
17,34311	5,953247	-3,57079	19,43561	30,33521	11,62344
20,41391	6,268555	1,206635	17,04929	30,21146	9,142853
22,63657	6,72934	12,33746	15,57159	30,02194	-15,7035
-4,62102	7,109863	23,38974	14,05676	30,2749	-28,4763
-8,95048	7,420868	6,289429	8,719574	26,63855	-28,0032
-9,41493	7,476349	-26,5777	-19,7806	18,89105	-27,929
-7,20504	7,798187	-26,8784	-21,5092	-2,76281	-26,5786
-6,26672	8,063385	-25,8845	-21,6658	-27,0896	-25,8569
-4,12124	9,011292	-25,0815	-18,0075	-25,5025	-24,386
-3,27826	9,442413	-23,6442	-14,8737	-24,0876	-23,419
-2,75796	9,728302	-13,5209	-12,2898	-23,6494	-21,7235
-1,9088	9,937744	-6,70499	-1,41317	-23,961	-19,3547
-0,64542	10,22052	-2,44282	9,769836	-23,549	-16,1247
1,137207	10,42581	-0,79333	17,28284	-21,7779	-7,19004
2,612274	10,75684	0,652405	25,13635	-20,8357	1,471008
3,146881	10,98434	2,092072	27,53305	-20,1582	8,550323

10,05222	-38,0126	-8,1056	-29,731	13,80862	0
1,486145	-40,2124	-26,4292	-28,204	2,395264	0
-28,3844	-45,4872	-33,3519	-26,9861	-24,67	-28,7256
-33,5128	-47,731	-34,4235	-23,2124	-27,7008	-26,9637
-30,6178	-47,3807	-34,3644	-12,0242	-26,197	-21,7577
-28,7864	-45,9379	-30,5181	-1,09085	-20,7869	-18,5815
-25,5949	-42,8745	-26,0567	3,517792	-16,2105	-14,3395
-19,4687	-39,796	-21,4769	3,846527	-12,534	-9,88645
-8,66859	-36,6649	-17,4801	8,247375	-7,63317	-7,43244
4,149628	-41,1996	-15,7633	-18,7218	0,302124	-6,27606
16,05313	-42,3309	-10,2575	-30,0456	6,851715	-7,61558
22,17093	-39,5525	-7,262	-28,2042	11,82697	-16,8095
23,07483	-34,7526	-6,30482	-25,7799	13,85522	-13,5633
22,9816	-30,4313	-5,39329	-19,3957	17,44708	-8,99963
22,46078	-28,518	-1,04659	-13,7607	18,90717	-4,80961
22,51321	-28,1505	1,243835	-11,9585	20,23782	4,451874
22,61353	0,180603	1,901733	-9,49836	21,39444	9,993927
22,47528	12,47766	1,995239	-6,56649	23,34583	12,51981
22,02719	2,144409	0,140869	-1,86223	23,18167	17,12845
21,78403	22,93536	-21,6813	6,418701	18,13263	22,45093
21,83115	24,29346	-29,6952	12,99451	6,644073	24,6731
22,49023	19,57343	-29,3004	-11,4382	5,155884	20,68503
20,31189	10,7485	-28,8173	-27,9423	-1,52282	17,90784
-21,4679	2,763672	-27,7308	-29,9577	-25,9164	17,00052
-28,9203	-3,73596	-20,7341	-31,0168	-28,9193	12,74136
-29,2217	-5,32835	-12,374	-29,8695	-26,7293	12,09265
-28,9413	-6,21859	-2,63574	-27,3123	-22,9709	10,86926
-27,8681	-7,3463	0,950745	-22,8378	-9,08858	10,06079
-26,2423	-7,63107	2,425537	-15,5535	7,823242	10,36899
-25,6755	-8,64124	4,950897	-7,78769	13,02295	9,463623
-23,5493	-8,71267	7,469482	0,490753	15,7258	9,100922
-21,4356	-6,51472	9,177917	2,575989	18,04376	8,564911
-21,2971	-0,26948	10,77908	6,791687	19,21753	-2,18333
-22,7607	-1,81718	11,58951	10,64349	19,90268	-9,18701
-24,5086	-3,25243	12,66455	13,10135	21,02652	5,980499
-24,9417	-3,31659	13,5311	12,93964	21,95319	-16,3411
-24,8692	-4,75408	12,48758	13,92484	22,78513	-32,7728
-24,4078	-5,88674	-27,1298	14,87061	21,31519	-26,696
-24,7133	-6,67649	-30,5469	13,63113	16,78757	-23,1649
-30,7802	-5,97517	-30,7344	13,4317	11,08481	-16,2711

-4,84483	-68,187
8,412598	-68,2511
23,37363	-69,2567
25,32074	-68,8635
27,74948	-68,8753
27,01636	-68,7887
26,4285	-68,9851
25,82632	-66,851
24,60376	-66,8771
23,03329	-65,532
20,27216	-64,1712
18,44748	-62,8598
14,93317	-60,003
10,46805	
4,437195	
-8,91471	
-47,4469	
-58,1836	
-42,3489	
-38,1839	
-34,3509	
-34,5781	
-39,969	
-45,4207	
-44,3568	
-48,2891	
-70,2197	
-85,1378	
-49,0164	
-61,2138	
-56,3598	
-48,0063	
-40,5177	
-38,3233	
-57,6394	
-61,2652	
-41,4088	
-39,1374	
-44,1998	
-66,0438	

Table A.19 Right wrist flexion/extension of S1 while playing to the rhythm game (first run)

3,51651	-40,5916	0	0	4,967621	8,900299
3,51001	-39,4698	0	0	11,82693	4,899231
3,51001	-36,3771	0	11,76813	12,42471	2,253143
3,505005	-33,0906	0	12,93741	12,36768	-0,97132
3,505005	-20,5808	0	13,27332	14,07535	-1,94304
3,474487	17,00101	0	9,550049	14,06989	-2,50676
3,474487	43,80994	0	7,688538	15,36432	-2,33162
3,474487	27,45456	0	7,172729	15,20676	-11,9408
3,443726	-52,0278	0	5,468292	15,12643	-58,9878
3,435608	-43,8269	0	2,25882	14,99197	-52,1241
3,435608	-48,203	0	0,8685	14,78705	-50,5353
3,36734	-49,9255	0	0,207825	14,63501	-46,7807
3,359467	-48,2014	0	0,043213	17,14926	-46,6239
3,379791	-45,0393	0	-1,86707	-14,6668	-43,6633
3,352325	-43,9433	0	-4,02806	-64,4185	-37,1369
3,373779	-40,9227	0	-4,03671	-61,0003	-33,3357
3,765259	-43,2024	0	-2,38854	-66,6949	-34,4037
3,997253	-39,4255	0	-2,14891	-67,0969	-34,7775
6,398163	-38,6966	0	-1,5325	-64,8326	-33,2738
7,310516	-37,1475	0	-1,11879	-61,2143	-31,0346
9,550354	-35,4839	0	-1,69656	-56,8459	-29,3365
9,268158	-34,6237	0	-2,35613	-55,8609	-22,5083
3,68158	-38,1003	0	-0,77565	-54,9823	-11,4086
9,37973	-35,7938	0	-2,12016	-53,539	-1,68967
17,70883	-33,5373	0	-3,12667	-54,2921	-0,641
1,799805	-36,152	0	-4,21665	-54,2294	-1,31734
-40,8045	-36,3994	0	-5,13023	-52,5312	-1,81294
-37,5032	-37,1286	0	-5,62658	-52,234	-1,10084
-46,8774	-29,5243	0	-5,87144	-48,0868	-1,61451
-43,4198	-9,54988	0	-6,21213	-45,2975	-2,14206
-36,6192	18,54315	0	-3,54875	-45,1221	-2,79375
-35,3961	25,54871	0	-18,0013	-41,7044	-2,60872
-39,0599	-3,62274	0	-64,1619	-36,5299	-2,56783
-38,7097	0	0	-43,2014	-27,8539	-2,46167
-39,4922	0	0	-56,3313	-9,97681	-2,34897
-39,9574	0	0	-50,7828	3,775085	-2,2325
-41,6187	0	0	-43,911	9,326172	-2,24261
-42,3478	0	0	-36,4465	7,769409	-2,08843
-42,3404	0	0	-25,5429	7,44516	-2,00346
-41,372	0	0	-11,3025	10,39471	-1,99773

-2,17943	-24,3481	-39,2133	-31,6394	-25,8976	-19,9183
-2,29542	-31,8015	-45,3098	-21,9722	-19,8704	-20,3637
-2,34987	-27,5183	-36,5765	-8,90537	-20,6244	-18,4551
-2,34859	-28,0795	-24,3995	-4,82189	-19,1571	-13,4776
-2,42358	-22,2069	-17,5443	1,995941	-15,5081	-17,5945
-2,47237	-14,4372	-14,5724	6,960754	-9,59731	-18,0696
-2,36379	-12,1279	-12,8839	8,594574	-1,37841	-18,0228
-2,21842	-4,34316	-9,02613	10,07544	4,031433	-17,2211
-2,06268	-1,22145	-7,13223	9,984802	4,88089	-13,8028
-2,18744	-0,17243	-7,93977	10,30725	4,955383	-9,6103
-1,77146	-0,3483	-4,62225	11,11072	7,18985	-8,25664
-1,93962	-0,18013	-2,03598	10,3345	9,030975	-1,5352
-1,91617	0,020874	-1,18113	11,78461	9,137207	0,610626
-2,69305	0,57663	-1,30102	9,616943	9,710785	-1,9398
-3,10886	1,613281	-1,17157	8,870941	10,84506	-1,86507
-3,7379	1,716492	-0,93112	0,864319	12,77731	-0,89092
-3,74678	1,788055	-0,74835	-34,131	18,83743	-0,25056
3,752136	2,086761	-0,91109	-58,5005	16,7551	2,182068
-14,846	2,240601	4,849823	-44,9194	6,815491	-22,9426
-42,3194	2,515778	21,17957	-37,615	2,360199	-38,6242
-29,3	2,823883	5,374512	-27,7424	-2,91426	-19,2754
-19,5417	3,536835	-46,9287	-22,4446	-23,9423	-15,5288
-16,1093	5,945221	-38,6935	-14,056	-30,8908	-11,8976
-15,4772	5,903687	-42,1615	-3,91884	-20,4383	-9,24531
-13,9331	6,251617	-39,824	4,430206	-19,1112	-8,54851
-12,5063	-3,6743	-28,5933	10,61133	-13,6447	-6,2165
-11,9554	-2,70347	-21,502	12,37082	-1,22767	-5,20563
-11,1998	-2,73871	-12,8511	12,66541	3,50473	-5,76326
-10,4693	-2,95484	-0,19905	13,18903	4,374817	-6,41957
-9,92854	-3,18714	4,918427	13,7298	4,690369	-6,70499
-10,0081	-3,23402	5,976929	13,48682	6,192657	-6,54013
-9,95194	-1,01292	6,183655	14,53207	6,842865	-5,44977
-9,87739	11,71881	6,128754	14,80933	6,906433	-5,72216
-9,6713	8,163849	6,256042	14,71021	7,381744	-48,2499
-9,54956	9,251617	6,72406	14,59622	7,662048	-40,6686
-9,44195	7,451477	8,92038	7,268005	8,538055	-39,1213
-8,0564	7,168671	14,97928	2,388885	25,04477	-31,1245
13,43954	9,055878	4,279877	4,55481	24,67599	-15,4411
22,15216	-2,87511	-44,8692	-15,3744	-11,3438	-5,61966
-18,4833	-52,4295	-36,7304	-39,6572	-31,0499	-0,47928

-0,45623	-40,7451	-5,3115	7,445618	-12,5149	-1,22306
0,173431	-39,965	-4,10388	7,99881	-11,109	1,678894
0,731079	-38,4082	-2,67436	8,300873	-9,4108	3,246307
0,894531	-33,3364	-3,32344	8,140625	-9,29994	3,068512
-0,59972	-31,5774	-3,30204	8,448151	-9,30493	3,605255
-3,20382	-29,4558	-3,02644	7,226532	-9,25646	5,747345
-3,4773	-25,9069	-2,98818	4,465515	-9,07106	5,996826
-2,14032	-26,3071	-3,97411	3,466522	-8,56932	5,997314
2,810028	-24,4584	-4,6543	2,472687	-5,8803	5,953033
-0,4177	-23,1775	-5,23728	2,230682	-4,70306	5,983612
-27,9324	-21,5367	-4,01459	2,176453	-4,54717	0
-28,475	-19,6206	-45,9948	2,77356	-5,23639	0
-28,2041	-20,0387	-34,2511	3,321259	-7,39969	19,35471
-26,1523	-23,0794	-23,8107	1,232697	-38,4643	15,45428
-24,4538	-21,8338	-18,0798	-21,8209	-45,8401	12,77618
-24,0428	-21,6515	-15,0647	-49,3572	-31,7993	1,360565
-24,2337	-4,43352	-12,4216	-43,2898	-33,4834	-42,1709
-23,6568	19,71573	-11,3625	-42,648	-22,6586	-38,6334
-27,132	24,56973	-10,2495	-34,8608	-15,0913	-42,0855
-27,466	13,95792	-9,25056	-17,1753	-9,15265	-37,0835
-24,656	8,584991	-8,92925	-8,50302	-4,18699	-20,9343
-19,527	3,170471	-8,10604	-4,60675	-0,40484	-0,82622
-15,5569	-4,70808	-7,08201	-1,60236	2,738922	3,911865
-7,0136	-12,7747	-6,1555	-0,62813	3,241882	8,347198
-5,23353	-13,8223	-5,30021	-0,05598	3,448029	9,308838
-5,08085	-14,296	-5,16306	0,291718	4,17215	10,45834
-5,55208	-13,9038	-4,73863	0,465393	4,269379	8,653534
-5,75929	-4,30277	-4,8369	-0,6455	4,591156	9,06012
-5,74256	1,3685	-4,88716	2,753479	2,572205	9,469818
-5,68579	-27,2666	-17,4398	-0,74113	1,483704	8,777679
-4,60244	-39,3087	-40,0496	-16,4806	-0,62991	8,047699
-4,75937	-36,6962	-36,6787	-42,5852	-27,9257	8,019318
-8,28221	-42,5561	-31,5995	-33,1241	-39,4681	7,721741
-6,89409	-25,3729	-25,2879	-31,4803	-35,2293	5,940643
-16,0232	-11,8345	-22,4119	-27,418	-36,0509	6,595306
-17,585	-10,8188	-19,6831	-22,049	-29,7221	7,054352
-18,3636	-9,02275	-2,90254	-18,3375	-17,3918	7,49707
-16,003	-7,62925	6,18222	-16,4748	-7,80409	7,263763
-17,968	-7,02288	6,472565	-13,8548	-4,38583	6,94043
-35,9383	-6,33455	6,831085	-12,9771	-2,49493	6,138123

5,541534	32,43756
0,872986	32,45993
-4,37549	33,92801
-12,0724	33,74554
-25,7997	34,7124
-49,2682	36,68213
-46,3439	38,01688
-31,2913	38,19135
-28,9851	38,02695
-22,5965	39,21359
-15,6921	37,95724
-12,2589	36,88956
-11,4921	36,63184
-11,1602	
-11,1775	
-16,387	
-43,4508	
-52,1994	
-48,9212	
-46,8168	
-52,5102	
-54,753	
-52,0384	
-45,1267	
-51,5807	
-75,9033	
-73,3501	
-56,7093	
-11,1394	
-2,608	
0,02002	
-5,04563	
-3,518	
-10,3693	
1,264923	
0,913025	
-20,6937	
-9,40543	
-0,67227	
23,6427	

Table A.20 Left wrist flexion/extension of S1 while playing to the rhythm game (first run)

Figure 5.30 – Second run

8,878662	14,1994	25,88654	26,87183	12,77866	19,70453
8,829926	10,55582	16,70685	23,57007	13,36432	19,91846
8,829926	-10,387	11,33707	16,92831	24,38654	19,92111
8,79187	-23,1793	-8,96053	15,16156	24,99344	10,02814
8,79187	-21,6598	-22,2771	10,03223	24,09772	0
8,79187	-17,9519	-19,9756	-9,81896	22,73047	0
8,709137	-16,4944	-18,8225	-8,91382	21,36026	0
8,709137	-13,7458	-17,3593	-10,7445	20,6113	0
8,642853	-6,29693	-17,0242	-9,51434	20,38849	0
8,642853	-2,32112	-16,2514	-9,16301	20,47891	0
8,642853	1,609039	-15,8128	-3,59757	20,57199	0
8,742218	3,909271	-13,5393	-3,39047	21,12769	0
8,869904	5,718414	-10,5078	-1,50461	21,54575	0
9,089417	6,318207	-4,08239	4,898804	21,95654	0
9,256775	7,452271	3,435394	8,629364	22,38031	0
-6,26104	7,984772	9,889557	10,46677	22,28384	0
-32,8345	7,768402	11,1387	10,50302	23,08228	0
-39,6041	7,816803	11,62753	10,54813	25,0184	0
-39,2492	8,409637	11,57269	10,76901	25,82336	0
-38,9262	10,23862	11,6402	11,32132	22,98233	0
-37,9067	10,35208	11,79291	11,96674	21,77444	0
-36,9313	10,55347	12,3067	12,64789	19,12082	0
-37,0193	12,09079	12,89862	13,11081	-2,5907	0
-36,8615	12,7843	15,33823	11,5014	-17,0581	0
-35,2418	-19,3453	3,796722	11,39291	-12,3772	0
-27,8782	-25,1853	-26,4608	-2,73653	-6,45002	0
-3,60143	-22,7036	-25,2985	-23,944	4,023956	0
10,4035	-21,8057	-25,7893	-25,0379	10,26779	0
18,25363	-19,883	-25,5024	-20,4717	13,39407	0
25,63132	-12,2342	-24,253	-16,726	15,88028	0
25,90845	7,123138	-20,434	-13,861	23,4118	0
23,37009	16,53012	-10,0045	-9,646	-6,73337	0
22,69183	17,21912	-4,42087	-1,53834	-23,422	0
21,31247	17,60895	8,995209	5,055298	-8,29723	0
20,52957	17,77603	31,71597	9,80423	-0,76236	0
20,44806	18,05444	36,33832	10,18454	10,54434	0
20,40622	0	34,81479	10,3844	13,43176	0
19,01556	0	32,45331	10,61768	14,16312	0
17,86807	0	30,51303	10,90854	15,83759	0
16,02454	0	28,67401	12,43036	18,3208	0

0	20,86429	0	30,83115	13,37631	21,80496
0	22,79114	24,47525	31,68353	14,48505	21,48236
0	23,42642	31,1402	31,6153	15,04337	20,10428
0	17,01379	40,79034	32,72641	15,46396	19,58664
0	17,20255	45,121	32,38879	15,66342	20,03839
0	5,275208	37,44818	36,08237	16,54553	20,58752
0	-21,1812	37,76447	37,43774	16,65805	19,46756
0	-21,9155	36,94489	9,77121	17,22626	12,57336
0	-22,5066	-3,51506	-18,7899	18,22827	-30,4398
0	-19,1547	-12,2932	-9,32749	-22,2338	-30,5287
0	-12,4762	-6,37396	-2,58833	-25,7255	-24,816
0	-1,99621	-3,33183	-0,9477	-23,6389	-14,3694
0	11,03464	8,346497	5,142365	-21,5762	-5,21871
0	17,57346	15,37326	-1,5871	-15,8517	1,526123
0	22,90125	-28,3248	-18,6093	-6,79362	2,282806
0	26,04492	-10,0782	-4,60953	0,82309	5,146393
0	25,77362	-6,06142	-9,24211	8,662567	7,159729
0	26,05219	2,536285	-2,18552	12,19653	10,23547
0	26,52921	12,65515	0,086578	12,36444	13,42395
0	27,5144	16,41519	9,605957	10,55237	13,93951
0	29,06476	17,64966	10,12292	8,361145	12,41718
12,59958	29,63556	23,40244	9,787781	6,404205	11,83105
13,92307	30,49551	23,35608	10,05643	6,171875	15,67651
15,25296	29,88467	24,16458	11,85172	11,80902	22,04602
16,97443	28,56326	28,63898	14,5462	18,25806	-27,1188
21,43167	31,76288	39,15939	20,95325	8,834442	-34,0312
25,98846	31,4259	26,17319	28,49442	-31,2584	-31,9018
-0,96936	30,59299	-27,0141	23,78952	-31,403	-28,0569
-25,4001	34,8324	-22,7831	23,69031	-29,2706	-24,2214
-16,9235	11,49887	-8,77854	27,33667	-25,99	-20,9918
-12,6104	-32,4447	4,197266	-13,1658	-18,2832	-15,439
-4,86216	-20,6514	15,04321	-13,774	-9,97768	-14,6213
1,426575	-18,3566	19,32138	-9,77171	-2,52224	-11,4422
5,96991	-10,7648	24,14276	3,972778	5,128021	-9,50941
10,73856	-1,471	26,70343	-13,8263	12,15353	-7,02345
15,83282	4,891724	26,81094	-3,17416	17,97638	-5,86059
18,82889	12,30933	29,103	-2,50706	19,94846	-1,69376
18,66046	15,59702	29,47528	0,331757	21,7403	-1,69714
19,08948	15,64709	29,97302	3,188751	20,72049	-1,17174
20,05792	17,7103	30,24835	8,131683	22,63977	-1,16588

-0,29465	13,32767	-3,22205	-31,7616	0,75119	15,77887
7,769104	11,16904	-26,6191	-28,1117	2,232361	20,17471
9,023499	-62,1712	-22,6264	-25,9523	2,942169	23,29974
7,1026	3,657715	-18,2706	-24,5688	4,527924	20,90613
-24,8892	9,648682	-13,488	-24,2992	8,333954	12,12939
-21,4965	-60,8724	-12,4627	-22,6172	-3,73724	-19,3497
-16,5421	-46,9747	-12,6399	-20,2538	-22,0971	-17,4176
-8,90432	-37,1847	-12,4879	-13,1874	-21,513	-16,2606
-8,93126	-49,8149	-3,59573	-10,6905	-14,6858	-16,5079
-5,24359	-47,0695	1,11615	-8,21495	1,95816	-15,7075
-4,03952	-37,51	3,284149	-6,63786	-33,1735	-20,4784
-3,15816	-21,658	3,71521	-5,20512	-33,7192	-36,9608
-2,38624	-2,28175	5,876678	-4,95632	-27,7146	-32,4851
-1,78414	-0,40947	6,206787	-4,19073	-19,0543	-25,6289
0,788422	4,562683	8,0495	-3,52884	-9,60785	-20,9168
2,810211	4,989349	10,45758	-2,48844	-2,22559	-11,9913
4,262726	1,679749	12,79221	0,499146	2,214935	-4,25149
6,457062	11,47412	12,18192	2,857422	6,953705	-1,94049
7,958344	21,01001	11,7496	-3,40024	6,179901	1,24588
9,749115	9,607361	10,83316	-28,0816	4,971405	0
13,14771	17,89844	9,042877	-36,5321	6,370026	0
6,619263	10,28125	-7,73389	-32,7516	7,742401	0
-18,256	-1,02378	-15,978	-31,4991	8,988495	11,16318
-14,1391	-4,84465	-8,84588	-30,2652	10,66211	11,31619
-13,8384	-9,92555	-27,9714	-27,5019	12,28241	10,37573
-3,95296	-9,96357	-28,0413	-21,2979	14,17896	10,10562
1,700806	-17,5049	-27,1147	-18,3693	-3,21483	9,076721
-31,5148	-17,073	-24,3628	-21,9627	-36,2014	8,234741
-18,8272	-17,5715	-21,9564	-36,2118	-35,2665	8,019958
-12,8273	-17,0608	-19,2973	-36,5228	-32,4917	8,097992
0,321167	-17,6763	-12,5058	-14,6743	-27,7517	13,05069
-0,88697	-18,2254	-1,92583	-32,0119	-21,6809	19,97467
-63,4978	-15,7421	1,713501	-19,3777	-10,6922	30,33807
-26,2382	-14,5682	4,333313	-12,0755	0,101318	13,98975
23,87671	-8,16892	5,058136	-7,39255	9,818787	-16,7331
-5,64444	-7,66582	5,971771	-6,32615	13,34122	-30,8512
0	-7,14987	6,529633	-5,33785	15,1618	-28,1978
25,43237	2,671478	6,864868	-4,37185	15,24982	-26,4207
9,478973	3,254944	8,141022	-2,879	14,15421	-23,0821
-46,4713	4,450043	0,813629	2,554108	14,42096	-19,6754

-15,4379	-45,9087
-9,67271	-45,4206
-5,78257	-52,6747
-1,49247	-52,3617
0,478302	-48,2166
-0,52588	-45,5106
-1,5039	-52,7489
-1,42183	-58,1577
-0,03438	-52,6977
0,763275	-60,1213
-0,15128	-65,4839
2,458221	-49,6481
1,546539	-49,4687
-11,6747	
-31,6033	
-47,4596	
-47,169	
-53,5104	
-66,7139	
-21,885	
-21,7915	
-28,2045	
-23,2715	
-24,559	
-28,4958	
-66,9842	
-57,2327	
-33,2911	
-58,613	
-63,3553	
-73,1674	
-54,4582	
-50,5659	
-51,4002	
-57,0126	
-51,7724	
-47,9964	
-47,2804	
-47,1452	
-47,1279	

Table A.21 Right wrist flexion/extension of S1 while playing to the rhythm game (second run)

-7,7864	5,125519	-15,3656	-18,1025	-38,1175	6,511566
-7,77507	9,931641	-13,0015	-17,7525	-36,6028	-31,2793
-7,77507	10,96292	0,577972	-13,7095	-33,8134	-31,9659
-7,76153	14,83948	16,0419	3,952301	-31,7467	-24,7582
-7,76153	15,40778	18,46988	15,4707	-19,7415	-20,7173
-7,76153	15,37833	18,03711	22,94537	-13,1653	-18,4339
-7,76697	15,14374	19,91599	22,87207	-9,2728	-16,8782
-7,76697	14,27853	17,49005	23,13943	-8,62667	-14,5697
-7,78461	13,42099	12,4736	22,51678	-8,12948	-10,1746
-7,78461	9,682465	12,46844	23,08301	-2,57575	-5,42088
-7,78461	8,072784	11,29178	23,24728	5,385803	-35,7137
-7,79271	18,33655	11,92163	23,22253	12,00125	-32,8458
-8,90191	12,43829	12,46777	22,8613	12,4718	-6,01784
-12,1606	-23,7888	12,7374	22,57443	9,458679	-5,38878
-12,4621	-28,4796	15,67209	22,86014	7,201172	-4,87933
-11,9603	-25,1148	16,93665	22,42203	10,0437	-3,03464
-10,7769	-19,5607	17,47433	14,58456	18,73355	-3,50849
-7,80866	-12,8466	8,555756	6,669556	20,92239	-3,92538
-8,42552	-0,14882	-20,7949	-1,9091	-13,05	-3,98015
-9,8591	-1,67865	-29,283	-9,27162	-28,6154	-3,77109
-9,50946	0,115784	-22,632	-50,1771	-19,2332	-3,91244
-10,1763	3,346436	-22,9714	-32,2191	-8,00415	-4,09673
-10,5156	8,312073	-23,072	-30,4308	3,841095	-4,23208
-10,6666	8,100403	-21,1858	-27,7064	7,164215	-4,3812
-10,7275	9,387115	-15,4997	-18,5185	10,19199	-21,1089
-10,5887	14,14185	-2,96849	-8,30283	10,53281	-51,6483
-9,56685	14,11014	7,810608	3,537811	11,6763	-32,0566
-9,14206	14,72345	14,84805	9,407196	11,59946	-29,3667
-6,82446	15,94775	14,40533	13,39774	11,83978	-24,0758
-6,46713	15,39066	13,87195	14,33762	11,97928	-21,1988
-6,73723	14,60379	13,37204	14,03961	12,09027	-15,9432
-7,03657	14,68762	12,99207	13,92053	12,12988	-9,64483
-3,2966	13,18954	14,83115	14,21292	12,49652	-8,70044
-22,5891	15,78897	0	14,60251	12,66495	-7,91811
-44,3186	17,56958	0	14,63748	14,17078	-7,1012
-38,1928	9,676666	0	12,89761	13,35275	-4,34527
-40,4502	-32,3835	0	7,896484	12,57187	-4,16935
-21,2854	-17,4234	-27,4039	-6,23649	12,63513	-3,68236
-2,71652	-15,5379	-18,7634	-41,3466	11,58658	-3,51983

-4,2934	9,03302	7,088165	4,354034	7,411316	-3,687
-4,9428	9,570221	6,831848	3,615234	6,510376	0
-4,66537	8,330292	6,299377	8,607941	4,713348	0
9,738129	-21,1803	14,02994	-1,45008	3,687073	0
-6,95341	-32,1121	-9,20932	-30,3132	2,604126	0
-36,6167	-10,4759	-47,3697	-40,3591	3,086761	22,89862
-29,3369	-8,54584	-33,6626	-40,1921	2,80658	17,83588
-35,4603	-5,01931	-37,4948	-35,9587	3,319092	11,68073
-20,4013	6,275085	-18,3405	-28,1375	0,743317	-6,73348
-8,18231	8,545593	3,516754	-12,9957	3,321716	-30,0916
-1,44439	9,439484	16,31927	-6,62234	13,21149	-25,5093
0,678101	9,842529	18,27927	-7,73119	2,456207	-23,9518
1,641174	9,964386	19,28754	-6,89013	-46,1704	-20,5607
1,742737	11,48193	18,70706	-5,28021	-22,6002	-8,44012
2,047272	11,1062	18,11987	2,279236	-24,5233	-4,29389
1,432861	10,81277	17,42053	3,120911	-20,6306	-10,0534
-0,17635	11,38211	16,58633	2,167572	-18,5552	-10,8414
-0,72999	11,98621	16,31467	1,301208	-14,2209	-11,3429
-1,26915	13,33353	15,33167	1,622406	-10,3442	-12,5302
-1,18076	15,92316	15,75311	1,71756	-4,87493	-13,3792
-1,00122	20,12674	16,00122	0,660675	-6,13992	-15,1719
-0,10289	21,78687	15,81549	0,376679	-4,94565	-12,5494
3,516052	-9,32868	16,03192	0,174866	-4,97224	-14,3354
14,1853	-20,2109	15,45023	0,310333	-4,97246	-13,6357
12,43796	-17,3516	15,03284	0	-4,49601	-13,6546
-37,6018	-4,44364	14,58408	12,21228	-3,36365	-13,7278
-27,8425	7,24881	14,01358	7,3815	-2,30061	-2,09754
-28,533	16,54657	-37,2531	8,769958	-0,92522	5,284973
-17,221	18,67032	-23,3004	9,163635	-47,1517	-26,2284
-9,27285	20,35809	-35,1376	-54,6025	-37,2315	-38,8397
-5,6591	-34,8283	-29,3379	-32,8071	-30,5408	-36,7773
-0,326	-13,3516	-25,7756	-30,1208	-33,4633	-39,1715
4,059448	-21,1961	-21,509	-30,1139	-24,7352	-24,0037
6,581818	-12,3054	-10,751	-22,2438	-17,4236	-15,3245
6,467926	-14,8952	-7,36387	-10,3917	-10,9003	-13,5561
5,890137	-1,35544	-5,29926	-0,82909	-8,10583	-14,769
6,205444	4,826691	-3,37048	5,447418	-7,12256	-13,4227
6,159363	7,538788	0,099792	5,547882	-7,17173	-13,4868
6,524628	7,734589	0,406494	5,674133	-4,2109	-13,0511

-9,90352	-18,2769	-13,4287	-15,5317	-10,5288	-25,7645
-5,19931	-22,8731	-14,0872	-15,3193	-9,78584	-19,7774
-27,4539	-21,5247	-16,1139	13,46716	-9,72549	-14,5709
-57,8564	-20,2635	-8,31114	9,788635	-10,6252	-12,6822
-31,3207	-21,567	-52,0288	3,912872	-12,0786	-10,8393
-31,7619	-27,9043	-46,2383	0,959961	-14,1639	-8,49641
-28,0672	-25,1957	-46,3733	0,924042	-13,7054	-8,52656
-21,975	-17,7939	-41,1437	-1,32753	-13,2578	-6,50494
-39,5397	-16,6451	-27,5092	-34,6764	-14,0637	-6,15807
-52,7498	-23,938	-14,2919	-35,7604	-12,1597	-5,31195
-35,419	-41,0457	-13,9985	-38,6534	-42,3209	-2,75868
-36,9069	-45,4448	-11,8317	-36,0802	-50,4301	-3,122
-30,7594	-44,6566	-11,5584	-29,8176	-45,7796	-6,6478
-27,6695	-43,5179	-11,2519	-20,3747	-42,7662	-21,7623
-25,966	-41,2448	-11,6747	-9,50589	-21,8342	-42,3163
-24,6649	-41,3558	-12,2414	-4,48438	-26,2771	-44,7769
-22,1215	-39,7602	-11,6747	-6,27831	-46,5411	-33,6219
-20,8833	-37,29	-11,7954	-7,76044	-31,2759	-29,9324
-19,9809	-36,3123	-10,609	-9,74767	-32,6721	-9,75421
-18,7797	-35,7539	-10,3924	-10,6796	-28,4447	3,86322
-17,2867	-37,425	-10,7236	-13,7768	-21,661	6,948914
-15,9788	-42,4675	-9,95157	-10,9583	-19,7703	7,160004
-15,7133	-34,6538	-9,28986	-21,6067	-18,4741	7,52597
-49,184	-44,235	-10,29	-20,575	-17,3133	7,10437
-34,9718	-23,8905	-11,0686	-20,2517	-15,4004	5,864594
-35,9384	-10,2376	-14,7491	-49,1956	-16,046	4,628265
-33,2574	-10,2818	-48,5996	-54,2062	-15,9054	2,946625
-26,0314	-15,5118	-47,6807	-49,2438	-16,6987	2,159241
-12,5427	-19,768	-44,7179	-48,2531	-17,1188	2,220215
-25,3842	-12,5835	-41,2272	-42,2409	-15,8937	4,646637
-7,76495	11,22836	-36,6621	-24,7064	-14,1802	4,773499
-12,9733	19,83585	-30,0459	-20,6379	-13,6618	3,348816
-19,2924	16,08453	-25,5396	-14,2442	-7,20408	-0,83531
-19,376	13,845	-26,6757	-13,1239	-23,8856	-27,4294
-18,9932	3,323029	-24,9168	-12,7214	-60,4542	-56,2287
-18,5644	-10,1	-21,7283	-10,9071	-41,4752	-41,1924
-18,882	-12,0619	-19,91	-10,0547	-43,2287	-37,9796
-18,5687	-15,9065	-19,1697	-10,3119	-36,2887	-30,6478
-18,9149	-15,7336	-18,2151	-10,4288	-32,01	-17,2755

0	-22,054
0	-18,6681
0	-8,11113
0	-6,20605
0	-4,92472
0	-5,56319
0	-2,43428
0	5,548462
0	11,01224
0	12,25153
0	8,916321
0	1,862274
0	-8,29646
0	-10,5281
0	-54,7786
0	-60,5337
0	-47,8129
0	-46,5349
0	-42,1704
0	-35,0096
2,930359	-36,1471
-11,6709	-38,558
0	-42,8524
-38,9635	-32,3672
-30,9024	-31,8175
-26,2592	-32,0229
-14,6352	-32,3356
-8,02173	-33,5096
-5,07841	-34,7193
-5,36643	-38,8643
-6,59052	-37,3581
-11,7391	-39,9367
-32,2972	
-45,869	
-49,1535	
-52,6679	
-62,8875	
-20,0142	
-13,3224	

Table A.22 Left wrist flexion/extension of S1 while playing to the rhythm game (second run)

Figure 5.31 – Extension/flexion

4,352264	-4,20159	-14,456	-40,9819	-38,9918	-14,7843	-17,6198	-42,7026	-44,3533
4,352264	-5,12835	-25,3443	-42,1054	-38,0612	-15,24	-44,4494	-42,9146	-45,4134
4,134888	-5,60806	-16,7429	-42,54	-31,3124	-15,6279	-33,1795	-42,4538	-41,7743
4,134888	-5,8468	-32,8191	-42,7974	-26,6353	-15,5068	10,12277	-41,8893	-38,6735
3,872253	-10,6034	-39,5054	-43,3488	-24,7421	-15,1846	8,673615	-42,2557	-36,7916
3,872253	-11,3789	-41,0418	-42,8205	-23,1061	-15,1459	3,412964	-42,0217	-35,7353
0,986633	-11,4287	-35,9233	-43,1818	-21,5358	-15,0508	-0,09604	-41,7801	-36,2565
-5,41174	-6,84836	-21,0081	-42,9791	-14,1788	-14,8076	-2,34778	-41,3444	-36,6438
-6,11124	-8,94441	-9,91245	-42,1862	-11,5678	-12,49	-2,13663	-47,1137	-31,4762
-8,06171	-10,7657	-5,7804	-38,836	-11,4259	-11,2261	-2,02007	-48,0473	-33,1486
-8,44465	-11,2619	-2,11084	-25,7425	-11,0464	-10,7474	-0,86748	-47,8472	-35,1271
-9,04056	-10,8671	-3,03775	-7,89795	-10,8028	-10,7038	2,41333	-47,7805	-36,4196
-8,32334	-11,6526	-4,06728	-3,66471	-10,5449	-10,8035	10,54849	-40,871	-33,0748
-10,1732	-26,7168	-6,95137	-4,03255	-9,38367	-10,7018	14,46613	-40,5659	-35,3507
-12,4493	-35,6301	-9,21363	-5,83692	-8,49805	-33,1307	15,34485	-42,0444	-35,8037
0	-40,1207	-9,15998	-10,0089	-7,81505	-63,3913	16,47131	-41,4851	-33,1544
-3,06822	-40,608	-11,0656	-10,0497	-7,72914	-3,90191	16,44284	-41,8528	-31,897
-2,90359	-41,399	-11,8479	-8,31799	-7,91524	5,632477	17,03824	-42,0643	
-2,70573	-41,0358	-11,1458	-5,52955	-8,27723	4,606171	16,68948	-41,9791	
-2,64851	-41,2019	-10,8743	-3,96988	-8,05646	4,741394	16,61108	-41,8518	
-2,2048	-40,6854	-11,7182	-3,03609	-7,84489	7,694427	17,50327	-41,4087	
-2,08173	-37,4318	-11,4055	-5,18678	-7,42754	4,72113	16,71533	-49,5627	
-2,77242	-36,5762	-11,7067	-1,64705	-6,81557	2,422455	15,08725	-50,0193	
-2,9093	-26,9735	-14,9225	-1,34833	-8,89663	1,678101	13,80508	-58,2975	
-1,81865	-21,9998	-29,483	-0,48079	-23,9018	-0,32018	11,93478	-59,7822	
-2,68836	-18,6402	-35,8208	-0,21677	-36,0187	-2,33648	9,995972	-61,8438	
-4,61669	-18,0843	-36,2586	-0,33939	-41,3897	-3,01228	2,209106	-54,5334	
-5,21963	-17,6556	-35,9988	-0,0662	-41,5553	-4,01674	-19,8519	-52,2609	
-5,0703	-15,0304	-35,073	-1,87774	-38,6265	-4,0717	-37,5448	-50,5032	
-5,17959	-11,0811	-35,7632	-23,2018	-37,0131	0,992279	-47,4785	-49,2115	
-6,40025	-8,62873	-37,5614	-38,9358	-36,3147	9,622192	-48,034	-47,7616	
-6,5405	-7,98944	-47,0618	-45,8334	-35,8789	14,20233	-46,7071	-45,2756	
-6,7376	-8,86665	-49,4027	-48,3462	-31,24	21,47565	-46,2423	-36,4926	
-4,48669	-10,2662	-50,6528	-48,7374	-26,8296	11,38513	-46,2044	-39,9463	
-3,8522	-8,23814	6,789398	-48,2178	-24,5926	8,988007	-45,2592	-37,8	
-7,0247	-6,15848	5,518951	-47,4095	-24,2815	11,50705	-44,5428	-36,4204	
-6,73411	-6,57207	1,588257	-45,9871	-22,7903	22,92245	-44,0117	-37,4614	
-4,70876	-9,88936	-12,018	-42,9167	-18,5691	20,41687	-43,6357	-39,1142	
-4,72577	-11,625	-27,0158	-42,0068	-14,6097	16,95297	-43,2736	-38,6246	
-1,37848	-13,0471	-36,3656	-39,7101	-14,3458	13,40201	-43,1485	-38,4002	

Table A.23 Right wrist extension/flexion of S1 while playing to the two hands mode of the flight simulator (first run)

-19,3677	-15,2598	-18,9265	-52,2125	-38,1228	-13,0966	7,678131	-45,8754	-46,584
-19,3677	-20,2702	-23,073	-66,8799	-27,0636	-17,3974	-24,5115	-47,2828	-49,0438
-19,2515	-21,8054	-25,8296	-72,8007	-16,3806	-18,9217	-17,8748	-48,2538	-48,4825
-19,2515	-27,0714	-39,5535	-72,6392	-13,3001	-19,3571	8,300293	-50,6448	-50,6348
-19,1477	-31,2747	-51,7654	-68,2719	-14,6924	-21,8234	6,241638	-50,0122	-52,1113
-19,1477	-31,0903	-57,7381	-66,0415	-18,6995	-23,8366	8,633514	-49,8647	-53,5998
-19,1927	-29,8833	-53,0944	-66,0967	-20,2979	-24,3949	3,445557	-49,1553	-53,8818
-17,1518	-21,7011	-30,8609	-66,0006	-15,7431	-24,5865	3,67511	-46,4077	-53,5194
-17,471	-19,3915	-26,9702	-64,0034	-14,2748	-17,0708	-0,71293	-41,9681	-53,0333
-13,1409	-17,0733	-18,2707	-56,6312	-15,1932	-18,0024	1,340546	-38,7119	-55,1712
-11,7641	-20,2438	-11,7394	-38,9163	-15,8442	-23,8833	5,438141	-37,4093	-57,1911
-10,6429	-21,4621	-5,45953	-17,5975	-15,9531	-26,2676	10,36716	-37,5382	-58,5514
-7,54589	-22,596	-1,71633	-5,72479	-15,95	-25,9523	24,12372	-36,2364	-58,3492
-5,32482	-37,3835	-3,5443	-5,43194	-15,492	-24,1457	28,09842	-47,9927	-59,0456
10,15277	-49,3421	-4,32624	-12,9462	-10,1067	-38,3995	28,30402	-49,6715	-59,9466
6,831146	-53,1938	-5,16917	-20,3619	-8,52944	-46,7403	29,2756	-46,8576	-60,8042
-13,7663	-51,6164	-7,66254	-21,3434	-9,90187	-3,90623	28,77576	-45,7823	-62
-15,5356	-50,5464	-8,46788	-16,7676	-10,7954	-1,09249	28,63354	-46,9371	
-16,5001	-48,3166	-9,30482	-16,1757	-10,7705	-2,6549	29,10837	-46,7479	
-16,8796	-47,0123	-10,2026	-14,8555	-11,0575	-5,33948	29,04984	-45,8426	
-17,276	-46,4511	-10,8369	-14,6833	-11,5152	-2,15222	28,68149	-43,1395	
-17,5127	-46,0355	-11,0504	-14,83	-11,864	-0,29512	28,48392	-47,0122	
-17,5519	-46,6711	-10,4523	-15,2957	-12,3205	-1,09665	27,64899	-45,6591	
-15,1818	-25,5941	-13,3624	-2,25028	-25,6877	-2,48648	27,43146	-43,6422	
-15,4664	-25,0939	-34,7525	-7,29176	-51,87	-4,30069	25,74069	-42,9916	
-16,1765	-28,048	-39,9171	-10,1501	-59,5672	-5,89872	24,06931	-42,5993	
-17,3659	-27,4604	-34,2424	-10,8458	-58,5171	-5,92335	14,80228	-42,7201	
-17,9834	-27,5401	-22,0712	-11,9439	-57,7556	-5,14154	-35,4647	-43,4105	
-17,1568	-25,8916	-24,9897	-11,5703	-55,8751	1,38855	-50,5159	-41,7361	
-15,5537	-19,0907	-24,9177	-38,5756	-50,5296	2,111816	-57,0595	-48,9831	
-16,2728	-16,1671	-28,5541	-48,3322	-47,8177	3,724579	-61,0764	-46,7284	
-16,7598	-15,5966	-38,3269	-51,5922	-46,4512	10,58496	-48,9547	-54,244	
-17,2056	-15,7502	-49,3798	-58,5281	-43,1227	21,17361	-47,4166	-48,8652	
-15,6909	-16,7097	-58,2673	-60,0283	-39,2049	20,29758	-46,8752	-42,0733	
-13,9526	-16,5387	-15,7546	-64,1829	-38,2635	11,57449	-47,2538	-36,9358	
-10,3056	-16,2221	-18,8398	-63,8702	-42,3425	19,43753	-47,4038	-40,3991	
-6,72746	-17,6201	-21,1074	-65,0979	-33,5788	33,89334	-46,307	-41,9314	
-5,09814	-18,8228	-37,2958	-63,26	-11,1392	24,21536	-46,5772	-42,5826	
-8,887	-19,0587	-52,1294	-61,6841	5,203003	21,06677	-46,7013	-43,2636	
-13,0707	-19,1555	-50,1994	-60,9021	-6,90474	18,41879	-46,1174	-42,8846	

Table A.24 Left wrist extension/flexion of S1 while playing to the two hands mode of the flight simulator (first run)

Figure 5.31 – Radial/ulnar deviation

-6,86389	14,81038	42,84568	-7,36493	-23,1619	-4,8009	-22,728	1,659576	12,79497
-6,86389	14,46341	19,27273	-6,43536	-23,6731	-4,75851	-66,6919	2,30779	5,032782
-6,80319	14,20171	1,078714	-5,44797	-29,5755	-4,91153	-45,7198	2,389386	1,146497
-6,80319	10,51142	1,984587	-4,08353	-31,3581	-5,34412	-3,83304	2,340623	1,244815
-6,7337	-7,70374	0,377019	-3,96063	-31,2501	-6,12558	18,09678	3,067403	2,503581
-6,7337	-6,42178	-0,0845	-3,85312	-31,2855	-6,24637	21,82116	3,835395	2,677876
-6,71783	-3,18552	-0,20227	-3,90042	-31,0138	-6,2225	22,30724	4,193645	3,119719
-5,7164	10,47585	28,8592	-3,82578	-27,8052	-6,08469	13,49014	4,317869	0,296972
-5,63107	19,21432	41,07606	-3,35687	-29,3658	-4,94074	1,910202	2,835332	-3,69898
-6,1539	21,52419	43,98749	-3,74689	-30,2403	-3,8624	0,745945	0,815736	2,551325
-6,58939	19,91022	44,83906	-3,55591	-30,7421	-3,32816	-1,73621	0,845472	-2,59616
-7,0918	18,00455	44,60561	-0,90491	-30,6505	-3,16049	-2,66931	-0,10669	-2,92395
-7,23789	17,43179	44,256	-5,76523	-29,8705	-3,28091	-2,86066	-1,00021	10,85189
-7,05734	16,80553	44,77161	-6,05139	-29,4082	-3,53998	-1,17218	7,433519	19,04132
-6,97278	13,31707	44,08964	-5,26617	-30,2785	4,106296	-0,42868	14,45291	25,10519
0	7,050881	43,8473	-11,1786	-30,5798	-19,8001	-0,24667	14,69771	28,41322
-0,93683	5,076488	43,67059	-16,7576	-30,8645	-5,59689	0,616271	14,42197	35,76559
-0,81671	4,639342	43,51816	-20,1068	-31,0127	-10,3004	0,341548	15,3408	
-0,64621	4,828434	42,61479	-24,1913	-30,6914	-11,5826	-0,03787	15,73549	
-0,41257	5,715849	42,04388	-26,1951	-30,1726	-11,3061	-1,34711	16,31861	
-0,49033	6,671341	41,20084	-26,6444	-29,6945	-9,80808	-0,06808	14,4694	
-0,521	6,780422	42,9744	-28,871	-29,0219	-9,04782	0,189659	1,722851	
0,340869	7,38401	43,53723	-29,9358	-27,8167	-7,97601	-0,24054	-5,99713	
2,847485	16,99726	19,51813	-30,8268	-17,418	-7,3786	-0,57132	-19,3881	
7,48209	24,90407	15,35171	-31,5554	-7,28647	-7,14087	-1,40741	-25,6562	
13,85432	26,49634	15,766	-31,2314	3,092044	-6,69989	-1,11084	-24,9753	
16,0485	27,78279	15,78518	-30,9147	4,05943	-6,69177	0,721075	-17,9032	
15,54833	28,11199	14,99562	-29,8413	2,724243	-6,68872	1,541051	-16,81	
14,81607	30,20417	14,88227	-28,2791	-1,77768	-6,92755	0,889564	-13,5747	
0,351995	33,09	15,41374	-20,5933	-2,40387	-7,43988	0,128504	-11,4216	
-7,90079	35,26147	13,30485	-14,6107	-3,14423	-6,21936	-1,43478	-8,99274	
-8,32654	36,65931	5,989059	-12,3343	-4,08627	-4,84638	-3,0159	-9,30838	
-8,29044	38,06151	6,152607	-7,90985	-6,4137	-1,45499	-3,72031	-3,81641	
-1,85724	40,53713	6,350663	-4,92694	-6,90369	-1,65677	-3,99646	6,272453	
16,93702	41,47591	-3,07877	-4,15668	-7,32794	-0,35031	-3,66806	19,93491	
23,48633	41,54402	-4,55182	-3,53296	-6,76456	-0,70551	-3,3894	25,41929	
19,91406	41,76477	-3,72357	-4,35529	-6,5589	2,044055	-2,68768	26,03462	
16,18243	42,71962	-6,86835	-6,17636	-8,04205	4,056891	-2,30673	27,27343	
15,38588	42,82992	-8,54141	-6,11289	-6,33682	4,410819	-1,52741	27,39727	
14,32772	43,16727	-9,92917	-7,56943	-4,94208	3,891146	1,460474	29,53272	

Table A.25 Right wrist radial/ulnar deviation of S1 while playing to the two hands mode of the flight simulator (first run)

6,051751	16,35132	23,73936	-20,1525	-30,3701	-5,23746	-9,22238	0,301507	-5,54077
6,051751	11,96613	22,40893	14,35255	-37,8673	-5,58563	4,072632	-2,53967	-7,15247
6,070337	11,60068	11,93791	8,576536	-36,6889	-5,47037	5,159495	-1,49738	-18,003
6,070337	-1,93973	5,893582	-3,17035	-37,6129	-5,04443	0,655709	1,205742	-22,5843
6,115376	-19,973	1,543237	2,558187	-37,4908	-6,49234	17,99232	-0,49857	-24,4227
6,115376	-19,079	-2,28357	1,282606	-35,9298	-5,85794	26,74145	0,115051	-27,2174
8,255497	-14,1028	2,996296	0,582226	-34,7018	-6,28622	24,596	-3,21408	-27,0967
10,60577	7,020072	25,86598	0,054225	-30,7439	-5,45783	22,34993	-23,395	-27,4762
11,22982	15,39839	32,16681	2,702022	-30,5925	4,522801	16,51759	-23,4475	-16,5085
10,4607	16,21739	29,31096	3,023162	-30,84	8,080127	7,551223	-18,7984	-10,0881
10,4938	17,18326	29,28489	-20,7701	-31,0389	8,587038	3,847608	-22,4973	-8,10492
9,309815	15,67736	29,77586	-21,1647	-31,0194	9,076677	5,913569	-22,0111	-16,7487
8,085871	15,22105	29,80443	-24,2385	-30,8052	9,784135	7,263059	-20,2921	-12,0554
7,840325	14,04106	30,15311	-25,5361	-31,0077	9,646059	7,172549	6,9278	-6,34122
0,822852	10,3244	30,09497	-25,2143	-33,7508	10,21791	6,691281	-2,97354	-14,597
-7,879	8,996529	29,99788	-26,7079	-36,1838	8,929474	5,132946	-2,5256	-18,7626
1,166722	3,522975	29,52749	-33,143	-37,0444	-0,55746	4,521767	-1,22788	-15,9695
-0,61649	2,307666	29,23187	-33,5249	-36,4222	-3,68466	3,75671	0,038587	
-1,48904	0,922341	28,86869	-33,4848	-35,9336	-4,54111	2,813947	0,293251	
-1,69684	0,524617	28,18528	-32,3631	-35,5296	-3,94888	2,215648	-0,52191	
-1,62888	0,713484	27,67215	-32,1924	-35,3359	-2,58829	2,121857	2,379938	
-1,53183	1,63937	27,30722	-32,6398	-35,0296	-1,93469	1,381883	-0,62891	
-0,08298	3,878754	27,12887	-32,9455	-34,4375	0,273575	0,421342	-2,81671	
4,719417	17,29228	16,13519	-38,3983	-20,0923	1,489175	0,148566	-5,84064	
6,661267	20,01876	9,263987	-36,4359	4,707774	2,218751	2,155736	-6,05032	
8,617164	21,05546	11,81896	-35,9499	17,17077	3,115819	3,5735	-4,69974	
10,22868	20,72167	16,91577	-35,669	18,26446	3,210332	4,121366	-11,5811	
9,827281	20,05768	19,57407	-35,2373	17,78158	4,159501	6,785297	-6,36279	
10,19637	22,0557	18,59781	-35,1375	9,707461	9,077523	22,97115	-8,07007	
-8,50913	24,74603	18,47942	-29,8993	9,454918	9,879451	24,23936	-6,76215	
-19,1648	25,90874	13,3499	-23,5598	6,729589	11,49066	-5,56284	-10,1027	
-19,481	25,89524	8,554205	-19,6188	5,870543	9,33036	-16,6015	-9,13123	
-19,8297	25,06941	3,908939	11,4016	2,177329	-9,7623	-0,6167	-11,825	
-7,55475	24,59451	5,379292	10,86419	1,156974	-4,75116	12,84807	-3,43344	
12,83784	24,85274	1,557767	-9,29614	0,603807	-2,26935	17,47068	13,92277	
21,10207	24,75383	2,265155	-4,30466	2,507178	6,002936	15,34905	4,08828	
20,52993	24,37874	2,183891	-11,2124	1,629954	8,268949	10,83487	6,569232	
19,05863	24,55201	-5,88831	-7,50818	-0,31027	9,975415	8,709348	4,284276	
18,47661	24,36573	-18,3401	9,256789	-4,38812	9,670192	7,477019	4,703213	
17,69009	24,01074	-17,6101	9,398841	-4,66742	9,95263	2,174226	7,427056	

Table A.26 Left wrist radial/ulnar deviation of S1 while playing to the two hands mode of the flight simulator (first run)

Figure 5.32 – Extension/flexion

-9,47098	-7,23703	-12,2287	-21,6973	-9,04602	-22,0665	24,99365	-33,244	-41
-9,28737	-8,98341	-11,8645	-21,2284	-10,5882	-12,7035	24,14917	-33,574	-33,7339
-9,28737	-7,49234	-12,6223	-20,8699	-12,0434	-8,29325	-0,76299	-33,1136	-40,3568
-9,33062	-8,18669	-12,2099	-20,4724	-13,2964	-8,08339	-17,4924	-32,3971	-49,5835
-9,43524	-8,95367	-13,9818	-20,1509	-13,3333	-8,27001	-17,8119	-37,5645	-47,9512
-9,43524	-11,0622	-13,8956	-19,9641	-13,7156	-9,29752	-16,451	-46,3569	-50,3079
-10,0075	-8,34357	-14,3946	-18,7036	-14,1272	-10,5277	-15,4987	-45,5576	-50,7132
-10,0965	-33,5229	-41,6126	-18,4629	-27,0604	-11,6536	-5,28802	-45,3074	-52,9317
-9,84095	-51,5061	-51,4378	-17,4616	-37,1323	-12,5156	25,73706	-45,0453	-50,6797
-9,98434	-48,7925	-54,9694	-17,6733	-40,4717	-12,8705	27,15103	-45,0516	-50,9666
-10,0176	-49,2011	-55,6618	-17,0739	-42,0692	-12,9338	23,4505	-44,2787	-49,9068
-10,2729	-48,7315	-56,1295	-16,801	-42,6537	-13,0768	21,97742	-43,062	-50,6361
-10,655	-48,1162	-57,0619	-16,9758	-42,4022	-13,1343	17,95825	-42,8374	-49,3571
-11,2944	-47,6835	-57,0381	-16,8143	-39,7282	-13,3084	3,353027	-41,2619	-46,1775
-9,32048	-46,423	-55,5747	-16,7044	-35,6671	-13,6265	-7,97884	-29,7162	-41,7194
-8,61056	-34,7681	-43,003	-16,3525	-24,7388	-13,5364	-10,1471	-24,1863	-38,0566
-8,70988	-17,7324	-28,6911	-16,0813	-24,1579	-12,477	-10,3282	-21,7565	
-6,37798	-14,1491	-22,6673	-15,7257	-26,5703	-12,2544	-7,67556	-23,4395	
-0,00942	-14,0985	-13,0141	-15,4577	-27,6365	-11,9744	-6,50704	-20,6565	
0,462494	-13,498	-8,22831	-15,3545	-27,9461	-2,08518	-6,33742	-36,8475	
-0,56331	-14,1361	-6,33564	-15,0331	-28,2615	-0,98638	0	-48,7097	
-1,3471	-13,7428	-5,89548	-15,0095	-28,6522	2,257172	5,557098	-8,00998	
-2,98535	-12,6908	-8,2562	-15,3394	-28,7572	6,977478	-19,9011	-20,62	
-3,12578	-6,12119	-10,5653	-14,9916	-28,8759	13,12366	8,573608	-29,1787	
-1,76632	-8,53708	-12,5905	-15,2825	-28,4221	19,98273	12,68826	-35,244	
-2,81458	-9,71874	-13,4775	-16,6388	-29,1556	31,93671	5,306946	-57,1183	
-4,53133	-10,5496	-13,9697	-37,414	-29,3552	32,75012	3,387512	-61,2949	
-9,94932	-8,87418	-13,7593	-41,9348	-29,366	32,61749	-0,03623	-52,2125	
-13,4848	-44,4501	-12,9822	-44,6315	-29,515	28,71494	-2,77526	-50,8214	
-16,4871	-43,8746	-11,016	-43,3597	-29,8718	18,74393	-3,28823	-49,8945	
-16,1388	-45,3494	-13,9172	-40,277	-29,6198	-10,7477	-2,8192	-52,82	
-12,4323	-40,4929	-11,9645	-37,5501	-29,2971	-20,874	-6,28095	-54,6049	
-11,1884	-29,1452	-10,7152	-35,5983	-29,4532	-20,1978	-15,3498	-26,7519	
-9,59723	-22,1957	-15,3182	-35,3501	-27,3193	-20,4261	-25,9508	-24,5735	
-9,21668	-21,0903	-18,5437	-28,2198	-26,083	-20,1226	-23,3398	-32,2389	
-8,96734	-21,1151	-19,5382	-20,1538	-24,8604	-2,40566	-27,4687	-41,5352	
-8,81596	-21,2356	-20,2537	-12,7348	-24,2039	30,18173	-28,2587	-49,8695	
-8,55303	-21,3075	-20,9084	-5,8343	-23,3214	34,68179	-28,8006	-53,0328	
-8,44933	-21,0474	-21,7673	-1,68776	-23,06	31,04538	-29,2154	8,03125	
-8,36874	-15,4079	-21,9675	-7,24111	-22,4676	26,68753	-29,1773	-2,27538	

Table A.27 Right wrist extension/flexion of S1 while playing to the two hands mode of the flight simulator (second run)

-15,6126	-6,48423	-15,1591	-22,2793	-18,1067	-16,2581	30,07333	-25,1391	-37,7537
-15,5763	-6,84048	-12,0954	-19,3094	-18,8036	-9,79001	32,71811	-24,1806	-25,2755
-15,5763	-6,98044	-10,4535	-18,8225	-20,4186	-7,83167	-6,10721	-34,9392	-43,7258
-15,5455	-7,21615	-9,869	-17,7366	-20,3198	-7,72188	-26,7905	-29,4166	-47,521
-15,4838	-7,46537	-9,90207	-17,5917	-18,5002	-8,65537	-23,3095	-29,0232	-44,4719
-15,4838	-8,04893	-10,2114	-18,068	-17,7278	-8,83937	-20,3778	-35,635	-45,3483
-14,5683	-8,68874	-10,4568	-10,5285	-18,314	-8,99738	-20,296	-43,3555	-53,7526
-12,8101	-30,7814	-23,4867	-9,73	-52,3856	-9,09361	1,925568	-43,6311	-58,7047
-12,6601	-54,5458	-34,6614	-9,46098	-52,907	-10,3674	38,14276	-41,6013	-54,8663
-13,2557	-44,8167	-51,0866	-9,64791	-55,194	-10,7117	36,10886	-39,2931	-52,3133
-13,1806	-43,4311	-50,6078	-10,9781	-57,7042	-10,7165	33,02237	-38,9308	-49,0426
-13,0318	-41,4622	-50,7935	-10,093	-60,2406	-10,6834	33,80939	-40,4751	-52,6908
-12,7835	-38,991	-49,1306	-9,96705	-55,2032	-10,6695	33,4881	-37,8289	-55,4493
-12,819	-37,4916	-47,7331	-9,77181	-53,5059	-10,8206	14,28482	-37,5798	-49,8357
-13,1659	-37,3795	-45,2956	-9,98199	-53,3381	-10,9964	-6,51613	-22,8003	-52,5902
-13,1572	-26,0856	-35,8699	-10,0329	-21,5036	-10,8135	-10,9355	-20,455	-55,0345
-12,1362	-16,7442	-21,3682	-10,1404	-17,6685	-10,1665	-12,2279	-20,5011	
5,94986	-17,7984	-21,5292	-10,4057	-19,9617	-9,98022	-11,6252	-19,9156	
7,86969	-18,8883	-11,8297	-10,5708	-21,9839	-9,629	-10,3903	-20,1517	
7,680481	-17,5431	-16,2386	-10,7568	-21,0875	0,533081	-9,70927	-19,884	
7,092499	-17,038	-19,0951	-11,1917	-22,9547	4,234314	4,87442	-41,6138	
6,426666	-16,866	-21,248	-11,6638	-24,1987	7,488617	5,74295	-21,1698	
6,000183	-16,9483	-23,0991	-12,1997	-25,9663	13,77191	-27,5297	-20,695	
5,370941	-15,7406	-24,7451	-12,4685	-27,8101	19,75436	7,379883	-31,2448	
4,804382	-14,505	-25,8775	-12,4531	-25,5563	22,27084	-8,01338	-50,3766	
4,053772	-14,2574	-26,5579	-13,4789	-28,9854	37,5014	-12,342	-66,1481	
4,071564	-14,138	-28,5576	-57,2077	-29,933	41,00482	-2,56052	-62,5366	
1,325165	-13,4279	-27,8675	-56,2885	-30,5106	40,45648	-6,22282	-61,4309	
-6,74294	-26,9706	-27,6457	-51,3919	-30,4108	39,966	-6,33668	-59,2295	
-7,85927	-35,1871	-27,5769	-44,3166	-30,9119	32,61472	-5,04392	-54,3929	
-7,89204	-38,5821	-28,2724	-45,4177	-31,0748	-0,64015	-6,41768	-52,7332	
-7,88799	-36,2393	-30,1194	-40,8695	-31,246	-18,7535	-16,8947	-51,4265	
-7,90845	-27,4989	-30,9087	-35,4435	-31,6353	-17,9463	-10,6146	-41,9984	
-7,78493	-26,925	-29,708	-36,3138	-16,605	-14,657	-13,4711	-29,5628	
-6,868	-26,8376	-26,0574	-29,9472	-16,9025	-12,0349	-24,1563	-40,1473	
-6,35752	-27,0242	-25,0179	-27,3756	-17,6735	4,105255	-29,8065	-48,2227	
-5,89075	-26,6933	-24,11	-11,5208	-17,4295	37,67166	-30,523	-54,4085	
-5,67617	-26,6796	-23,7474	-2,02782	-17,4651	44,36911	-29,0328	-53,6222	
-5,67252	-26,5316	-23,5906	-10,8958	-18,1069	37,47559	-27,3643	-12,1455	
-6,05542	-15,8794	-24,0032	-16,6191	-17,9826	33,25015	-25,9449	-9,80557	

Table A.28 Left wrist extension/flexion of S1 while playing to the two hands mode of the flight simulator (second run)

Figure 5.32 – Radial/ulnar deviation

-1,12042	27,66545	41,87561	-8,33939	-19,3141	-7,25363	-6,81476	-5,11392	8,845832
-1,09973	32,56985	41,80473	-8,81152	-19,0482	-2,79327	-6,70593	-3,96158	3,327114
-1,09973	35,81742	41,44149	-9,70978	-18,686	-1,09454	5,152608	-0,32523	5,087208
-1,1051	36,30308	41,40917	-10,3666	-18,2284	-1,14185	13,5187	-1,9343	-0,77802
-1,11649	36,20015	42,29796	-11,1848	-17,8132	-0,75635	20,284	1,676979	-3,09503
-1,11649	36,49573	42,06459	-14,156	-17,5192	-0,82462	21,49632	4,772143	-1,3374
-1,39249	36,95761	42,87578	-18,2235	-17,2234	-1,12238	16,64517	4,570888	-1,80606
-1,63776	20,90118	41,26316	-20,6255	-8,95963	-1,28174	11,21955	4,931185	1,263121
-1,67236	2,811208	30,79496	-19,9944	-3,04669	-1,35974	7,764692	5,085983	2,636505
-1,4661	-1,78659	21,75531	-19,7477	-0,43274	-1,43265	-0,19205	5,454242	2,415576
-1,52817	-3,20328	22,54202	-19,6006	-0,48093	-1,4744	-0,98669	5,550751	12,52747
-1,5065	-2,49197	0,518726	-19,2353	-1,63687	-1,51749	-1,78833	6,278545	15,33949
-1,53354	-2,54385	21,07761	-18,9316	-2,99664	-1,5242	-2,01025	6,611094	7,890465
-1,60236	-2,54614	20,86696	-18,4282	-4,69202	-1,54117	3,092027	6,75245	14,99683
-1,2869	-0,77081	21,11316	-17,9888	-8,25305	-1,55719	12,51407	8,777285	37,4418
-1,04038	11,34471	21,88506	-17,5533	-17,2686	-1,44955	18,68453	17,22417	49,85809
-0,92749	33,69918	25,23975	-17,1459	-23,157	-1,2514	18,30014	23,06292	
-2,58685	36,57146	28,86642	-17,0966	-22,6316	-1,1593	16,07442	21,26603	
-4,42789	37,53009	40,34825	-17,0694	-21,6999	-1,35535	16,14967	19,74654	
-3,90707	37,40804	41,06516	-17,0215	-20,0703	-2,19299	16,96507	6,273738	
-3,49396	36,77717	40,49662	-16,8742	-19,7704	-3,4133	0	-11,0849	
-2,90076	36,43834	40,53956	-16,6205	-18,5263	-3,62323	-8,09943	6,295748	
-3,01587	36,06845	39,01155	-16,2705	-17,9112	-3,15088	-11,7847	-1,16058	
-2,6673	35,42254	35,65992	-16,1257	-17,8783	-3,78967	-1,4628	-7,77329	
-1,95996	35,93127	34,84485	-16,1305	-12,6863	-5,93939	16,32229	-10,2653	
-2,35358	37,87551	34,20731	-16,1263	-11,2714	-7,5947	13,72399	-4,94333	
-2,56018	38,87841	33,76727	-12,005	-10,8232	-6,57016	21,52037	-11,3342	
-2,53241	34,66117	33,92172	-9,68326	-10,9496	-6,80756	24,54477	-4,57993	
4,876679	-1,07208	34,00058	-7,4343	-11,2559	-6,80399	22,70862	-3,86017	
16,43484	-5,55344	32,50476	-8,75238	-11,0981	-4,59927	21,28725	-3,49976	
22,96596	-5,76074	29,69221	-9,60083	-11,0677	-5,53424	19,45573	-6,44754	
28,10724	-1,38312	20,96368	-10,255	-11,3291	-3,30231	8,859157	-8,93936	
28,64302	28,90538	10,97726	-10,261	-11,539	-2,42798	-4,08771	13,63219	
28,14515	39,74947	-1,11588	-9,98834	-7,65085	-1,72009	-10,1364	-0,88101	
27,57384	39,31568	-3,60547	-10,9899	-6,43732	-1,98477	-5,82575	1,946268	
26,74937	39,17806	-4,71182	-9,66974	-5,05804	-0,47772	-5,85849	-4,53735	
26,51042	38,6703	-5,25559	-12,5083	-5,07196	6,22442	-6,58026	-7,09277	
25,64194	38,15745	-5,50797	-15,7217	-5,73254	1,085327	-6,24774	-19,5769	
25,87318	37,89678	-6,96616	-18,195	-6,16309	-2,32813	-5,61179	9,523684	
26,24887	40,11704	-8,10266	-19,1051	-6,62552	-6,17862	-4,96918	4,766718	

Table A.29 Right wrist radial/ulnar deviation of S1 while playing to the two hands mode of the flight simulator (second run)

2,572629	20,14278	25,73172	-7,85898	-33,4188	10,50262	6,265666	-4,63977	4,91474
2,498812	21,62938	28,15382	-6,16538	-33,4834	16,36747	-7,01773	-2,79031	0,327882
2,498812	23,42813	28,03805	-5,35986	-33,6891	18,97356	9,966871	-0,72714	9,062778
2,443168	23,96652	27,51146	-5,11649	-33,4468	18,80477	20,94558	-2,43701	0,627616
2,355212	23,76138	27,17173	-6,07114	-32,9067	17,78847	22,54747	-7,02173	-7,2919
2,355212	23,44534	26,8851	-11,1415	-32,816	17,48671	21,69119	0,228218	-11,0728
1,123514	23,03757	26,69238	-24,6292	-32,2057	17,29704	20,04132	-5,3367	-10,6593
0,278117	14,9945	26,89441	-26,2351	2,284198	17,00465	15,01294	-11,7135	-6,89676
0,218649	0,706167	25,47966	-26,6096	7,131246	15,99922	-5,64609	-13,1339	-12,2163
0,163107	-0,46799	20,339	-26,9816	10,38931	15,375	-6,51663	-14,8477	-17,5669
0,077943	-4,39417	14,26788	-29,8083	9,538744	15,47978	-14,0822	-16,1336	-32,6621
0,099684	-4,25806	15,72734	-29,5941	15,19524	15,51177	-12,1289	-15,1468	-26,4098
0,358801	-4,33481	17,2555	-29,4329	23,14251	15,46287	-11,9637	-16,3297	-22,9549
0,808372	-2,17255	19,98806	-29,1441	15,33258	15,52304	9,443278	-13,188	-24,252
1,033462	4,097421	20,06958	-29,1694	2,838245	15,6163	23,11794	4,011301	-0,59229
1,101542	11,23538	18,48761	-27,6081	-22,8936	15,86004	24,56969	10,62108	-4,37534
1,349741	22,67943	21,46816	-27,3774	-31,4558	15,63835	23,20038	13,18135	
5,213005	22,46311	22,64531	-27,0189	-31,6419	15,43175	22,60522	12,49234	
4,833872	22,47179	22,90528	-26,6429	-31,5199	15,22269	22,2091	12,70494	
4,471428	23,37263	23,71471	-26,2596	-31,274	19,61512	22,64002	11,47424	
3,690922	22,9985	22,67144	-26,211	-30,7756	20,70091	25,00355	8,262007	
2,886587	22,11466	22,05508	-26,3371	-29,542	19,34387	9,618853	12,21355	
2,424754	21,88261	21,72055	-26,2443	-28,2526	17,67485	13,01551	6,066181	
2,053068	20,92484	21,51455	-26	-26,1879	17,73886	8,020352	9,620796	
1,843712	20,7137	21,24514	-25,9914	-5,54794	16,01699	20,77878	17,44283	
1,748316	20,87447	20,63096	-24,4403	-6,6344	2,46719	26,48669	12,55931	
1,606051	21,44985	20,84786	-17,5397	-7,19235	-0,34836	26,6964	4,513768	
1,965067	22,1807	21,27335	-8,42307	-7,76883	-2,05487	27,69353	10,20603	
6,671838	26,96954	21,25336	-11,2516	-7,85382	-4,66428	26,7866	9,765438	
18,78264	29,78022	21,41195	-10,2834	-8,00601	-0,75433	26,12666	-4,30176	
24,5177	25,8354	22,21591	2,278101	-8,5423	14,73746	23,20877	-9,67242	
25,14853	27,55405	23,00287	8,545187	-8,65271	16,00464	7,617046	-9,71997	
24,70164	27,12614	22,13076	18,18745	-8,21082	15,16309	5,975628	13,54522	
22,81716	27,70601	13,20846	16,30471	2,773355	16,01095	1,266743	15,42558	
21,58112	27,06218	7,973978	7,403147	9,86443	17,54094	-0,56308	14,48373	
21,26179	25,78056	5,482042	-3,92804	10,5301	19,55597	-3,39475	14,471	
20,90023	25,09643	3,789941	-11,0337	10,88021	-1,17279	-5,44647	41,96167	
20,55925	24,69563	2,82678	-22,01	10,55035	-0,62643	-5,30087	8,277527	
20,3712	24,4951	-1,96292	-29,1867	10,49984	5,535165	-5,38364	5,622357	
19,86066	25,14648	-8,47208	-33,2228	10,11849	8,814696	-5,24616	2,351636	

Table A.30 Left wrist radial/ulnar deviation of S1 while playing to the two hands mode of the flight simulator (second run)

Figure 5.33

1,669891	-17,0966	-15,9231	0,593964	0,760101	-27,4876	23,93314	3,798096	-32,6814
1,669891	-22,9718	-15,3416	3,332825	0,109039	-30,6113	23,64127	3,75885	-28,7603
1,669891	-25,8809	-14,9319	2,756073	0,451752	-33,9599	23,51489	-24,6071	-24,739
1,792999	-27,2736	-15,0232	3,193024	0,607056	-42,3302	22,95877	-42,5036	-25,0589
1,792999	-26,1746	-15,1348	3,496429	0,839447	-47,4651	22,81598	-50,5696	-36,4758
1,903137	-21,6921	-15,0788	3,876007	1,197662	-47,4823	25,23911	-50,393	-54,055
2,826904	-20,3774	-14,9801	4,825134	1,166718	-34,4808	31,23016	-47,7956	-56,381
3,638519	-18,9523	-15,8914	5,235962	-9,0191	0,563507	34,60126	-46,7057	-57,2851
3,698761	-13,965	-16,0051	4,954529	-24,3958	11,32025	29,98767	-47,0602	-58,6649
3,534882	-8,48705	-14,4161	5,027496	-30,2662	20,42871	30,927	-46,6429	-61,3741
4,066559	-4,21215	-13,2694	5,1922	-34,4093	27,70154	30,75195	-46,1152	-64,8931
4,857483	-1,53941	-13,0421	5,229126	-33,1964	27,96771	29,35477	-46,0366	-72,9679
2,618011	-3,50749	-13,0539	-16,2816	-33,019	27,47443	9,790466	-45,5535	-75,6607
-0,47919	-2,49858	-13,5681	-18,273	-34,242	17,93378	1,358978	-45,7318	-74,9618
-3,19529	-1,00637	-13,3733	-21,4952	-34,4522	-1,32344	-3,14569	-39,9874	-46,1355
-3,24843	-2,50339	-10,9986	-21,922	-15,9153	-2,271	-6,90426	-28,5485	-32,1337
-3,72007	-2,94186	-10,4924	-22,8544	-3,26721	-1,20335	-11,8601	-25,2063	-28,6535
-1,79434	-3,35639	-10,218	-22,6238	-1,31019	12,40149	-14,5293	-22,7675	
-1,84587	-2,9272	-10,2524	-21,2843	-1,74342	14,23004	-13,9271	-20,711	
-1,91012	-3,00358	-9,23697	-19,9333	-3,17446	14,21454	-8,23832	-19,3461	
-2,29047	-3,50603	-11,5179	-18,2547	-4,80364	15,22635	9,400696	-18,0909	
18,69186	-2,95662	-17,4459	-16,5203	-4,63151	15,75296	16,05618	-17,0576	
22,24527	-3,16327	-18,778	-11,0295	-4,4496	15,59396	19,43591	-17,2988	
26,06293	-3,6385	-18,9225	5,378021	-3,87178	15,1416	19,06287	-17,35	
27,02777	-3,98914	-19,2073	3,461975	-3,77817	15,08191	18,4595	-17,1511	
29,16229	-4,65816	-19,3187	2,328735	-3,70914	14,84525	18,34805	-17,5918	
30,08215	-5,62332	-19,1137	1,501892	-3,56043	14,53073	18,25204	-17,8311	
30,02249	-11,7018	-19,2212	1,201691	-3,77675	14,79233	17,78729	-17,9	
34,15878	-26,9539	-19,202	0,136597	-3,4372	15,16434	16,94409	-16,8205	
34,74747	-28,176	-18,9495	-0,12239	-1,55986	15,90048	16,71387	-16,507	
28,57196	-21,0893	-16,3079	-0,25365	2,65033	16,30853	14,36682	-16,9066	
16,96698	-11,5922	-10,5272	-0,46972	2,725006	16,34485	6,180115	-16,4728	
0,823547	-14,5874	-9,67664	-0,53576	-13,8045	20,66541	3,968384	-30,4764	
-1,14368	-14,7418	-9,9276	-0,64474	-23,9206	24,24454	3,700287	-29,898	
-1,40513	-15,2779	-10,144	-0,51354	-28,9642	24,55054	3,263611	-31,9442	
-1,482	-15,6211	-9,85935	-0,50008	-30,938	25,23154	3,477356	-32,1396	
-1,38699	-16,1184	-9,56222	-0,49723	-30,5562	25,79178	3,698212	-31,413	
-1,29345	-16,2686	-13,4629	-0,17823	-31,1184	25,57059	3,903381	-24,508	
-1,51965	-16,2938	-10,9199	0,492584	-31,4105	24,84818	4,063934	-28,8917	
-8,93272	-16,3513	-3,96937	1,943237	-29,8538	23,30917	4,017181	-27,4273	

Table A.31 Wrist extension/flexion of S1 while playing to the one hand mode of the flight simulator (first run)

-10,2538	-7,09576	33,16822	-20,4124	-46,6836	-7,45212	-14,6667	-10,2305	-21,0967
-10,2538	-7,51932	33,24022	-23,819	-50,3306	-5,79791	-14,3603	-10,1859	-24,833
-10,2538	-6,06815	33,83577	-24,6706	-49,2809	-4,91388	-13,872	-4,26575	-14,0322
-10,1582	-5,32404	33,91215	-23,8754	-48,2336	-1,53983	-14,4882	-3,10031	-10,2771
-10,1582	-6,1506	33,79499	-23,7125	-47,9212	3,113464	-14,7894	-6,22516	-13,5822
-10,0859	-5,49982	33,58341	-23,4072	-47,5299	2,463561	-15,5657	-6,4639	-21,5989
-9,21436	-6,15976	33,31863	-24,199	-47,2818	-5,82599	-11,901	-4,41782	-21,686
-9,31686	-5,78522	16,8557	-24,237	-30,0354	-14,0595	-9,37802	-2,75009	-19,4639
-9,32828	-4,6409	0,23887	-23,6938	-18,4116	-21,9849	-11,1366	-2,21979	-20,8873
-9,12637	-3,54358	-2,07889	-23,7106	-8,87824	-16,7314	-12,2642	-1,4346	-25,3162
-8,48575	-1,24609	-2,52762	-24,7099	-4,12439	-11,0395	-11,5536	-0,68689	-36,8919
-7,93561	4,488562	-2,02271	-24,3909	-3,9375	-8,88312	-13,4432	-0,71851	-49,344
-10,7624	8,633747	-1,28708	-15,701	-4,27368	-9,71246	-7,56845	-0,18237	-61,5627
-11,5392	13,04365	1,272766	-10,4855	-5,4949	-8,04562	-8,88983	-0,9082	-77,9819
-10,6464	15,23396	8,866037	-7,47287	-7,55765	-5,04742	-9,04691	-3,11411	6,71374
-10,435	15,1581	16,65627	-6,10062	-15,285	-5,17517	-9,54099	-14,8966	30,87611
-8,50211	15,19755	23,91105	-5,96741	-30,3858	-5,87811	-9,02548	-13,1168	38,52002
-9,02011	15,26783	24,91375	-5,91214	-38,3704	-5,01767	-7,06183	-13,0509	
-8,76645	15,18578	25,31133	-5,8172	-39,57	-3,67984	-6,73383	-12,1034	
-8,79697	15,11885	24,31429	-4,55216	-38,5778	-4,69656	-9,63767	-10,3954	
-9,01694	14,83177	9,422504	-14,5801	-37,4778	-4,9216	-7,61295	-9,84534	
-1,90903	14,94383	-0,4827	-15,8745	-37,149	-4,96942	-6,83817	-9,59906	
-2,53204	17,1634	-1,48932	-17,9655	-36,9283	-4,92868	-8,42624	-9,2916	
-3,98349	16,49216	-1,49051	-28,1385	-36,9778	-4,21777	-8,45828	-9,12161	
-6,15225	16,4982	-1,15109	-30,4157	-36,4168	-4,68848	-8,0668	-9,07144	
-6,34259	17,2294	-1,18866	-32,8422	-35,5471	-4,72955	-7,6608	-9,17557	
-6,87567	16,54767	-0,91992	-33,0506	-34,9789	-4,78168	-7,57303	-9,06836	
-7,46429	3,471931	-0,71735	-33,1833	-34,6286	-5,22046	-7,78543	-8,28989	
-9,75128	-6,03958	-0,80081	-36,9999	-34,4356	-5,2435	-7,94803	-7,8057	
-10,1713	-5,51315	-1,04135	-37,6597	-36,5158	-5,41351	-8,2558	-7,33606	
-9,4339	1,256258	-7,85107	-37,9189	-44,4143	-5,69031	-8,56741	-7,30948	
-5,0293	27,18802	-13,7421	-38,0767	-45,1624	-6,44736	-10,5825	-8,32675	
-4,91473	34,16901	-12,6066	-38,1289	-27,3962	-7,09943	-10,3152	-8,60495	
-4,87506	34,54641	-11,5417	-37,8648	-10,4378	-7,95978	-10,3657	-7,89835	
-4,89996	33,20893	-11,6439	-37,659	-4,22772	-11,9242	-10,5313	-6,70584	
-4,79239	32,9108	-11,1829	-37,6641	-3,69531	-12,9275	-10,447	-6,04791	
-5,01492	32,83171	-11,0341	-37,7579	-4,8302	-14,001	-10,244	-4,17163	
-5,11398	32,67974	-12,8355	-37,3442	-6,08371	-13,6891	-10,195	-6,26056	
-5,35208	33,37964	-13,2911	-37,2802	-5,98401	-14,8156	-10,1136	-13,6382	
-5,754	33,41654	-15,7801	-32,0441	-6,90808	-15,3252	-10,0926	-13,5502	

Table A.32 Wrist radial/ulnar deviation of S1 while playing to the one hand mode of the flight simulator (first run)

Figure 5.34

1,804535	-2,46664	-5,90869	-14,3603	0,086395	-1,12629	20,03491	-0,74772	8,81958
1,804535	-2,43161	-9,04619	-12,0213	-0,86284	-2,43312	24,34909	14,70435	7,297974
1,804535	-2,43186	-13,6689	-9,09635	-1,26641	-2,62607	29,00375	-19,3277	6,189484
1,82019	-2,27653	-13,087	-9,2132	-3,79221	-3,39809	37,41852	-21,5508	1,687347
1,82019	-2,21514	-12,6589	-9,63788	-4,72403	-4,30367	35,04123	-16,8073	-1,952
1,82019	-2,22459	-12,0978	-9,37216	-5,85772	1,037109	35,62576	-17,0428	-27,9693
1,822327	-2,17559	-11,6566	-8,36052	-7,02348	1,009094	38,93399	-17,3953	-51,5977
1,929474	-1,57835	-9,12718	-7,54985	-7,6028	1,111115	36,0173	-24,5741	-53,5153
2,02713	-1,80897	-9,09792	-6,64166	-8,03579	0,990265	26,25037	-24,3366	-53,9734
1,810364	-2,64953	-8,65219	-5,93741	-8,05238	0,95694	27,58398	-25,4775	-52,396
1,518402	-2,93353	-3,09091	-5,56503	-8,02306	0,970429	28,92996	-25,181	-51,5792
1,222137	-2,68331	-4,99208	-5,2984	-6,40258	0,780335	41,23059	-23,3517	-51,8196
0,543549	-2,90237	-5,74136	-4,96782	-7,05421	0,784363	47,29733	-24,3804	-55,2606
0,258667	-3,3585	-6,98635	-4,56644	-4,51149	0,234741	49,77478	-34,1486	-46,5095
-0,47771	-3,56828	-7,55316	-4,49086	-8,05781	-0,00568	48,54929	-37,2629	-36,4634
-0,91041	-4,04022	-8,47193	-4,28949	-26,746	-0,231	37,98584	-38,3358	-34,7661
-0,9378	-2,99414	-8,47621	-3,42898	-46,3297	0,102753	13,49017	-39,5449	-34,4197
-0,94294	-2,57041	-8,38604	-2,66076	-50,7515	16,73123	-20,4405	-40,8418	
-1,15548	-2,18804	-7,42675	-1,84988	-35,4451	16,63785	-30,1525	-42,5	
-1,58587	-2,30005	-7,2405	-1,67486	-10,5546	15,32001	-25,8652	-42,9733	
-1,86028	-2,08875	-7,47859	-1,50067	-11,6394	15,16779	-25,8148	-44,5115	
-2,18065	-1,95643	-7,50489	-1,36963	-12,2444	14,44757	-21,9253	-46,3313	
-2,46935	-2,0033	-6,87537	-1,29514	-10,1961	13,68756	-18,795	-46,8689	
-2,02561	-3,02486	-6,47611	0,315796	-8,76754	13,0087	25,59329	-46,6359	
3,301331	-1,17491	-4,19901	2,312592	-8,18877	12,3334	39,896	-50,6641	
4,521088	-0,86552	-2,58861	-0,06615	-8,10857	11,85992	39,16321	-45,723	
5,190369	-0,59379	-0,57791	-0,7243	-6,79748	11,3291	38,32962	-44,2335	
6,162476	-1,27388	-0,12436	-1,70177	-7,96466	10,98041	36,33508	-43,4139	
6,641815	-1,53789	0,118134	-1,26787	-11,2302	15,30838	28,78043	-44,2055	
7,095856	-1,6698	0,185974	-0,66336	-9,07762	22,48773	26,10876	-46,4538	
7,243042	-1,81185	0,077606	-0,45542	-9,19583	21,14575	24,72711	-47,5097	
7,138062	-2,03837	-0,06203	-0,26299	-9,75483	20,992	24,99994	-48,2626	
2,61853	-2,57047	-0,34323	0,254181	-10,4234	19,5051	25,49866	-49,3333	
1,331726	-3,2754	-0,62019	2,589661	-10,7228	13,07257	24,65057	-49,9826	
0,076996	-3,76607	-0,93155	2,496674	-10,9175	5,331604	7,444061	-51,5509	
-0,63457	-2,56953	-1,08417	2,714386	-8,08804	5,800171	-2,42644	-52,4785	
-1,50356	0,339447	-6,58771	3,295776	-2,91607	22,72446	-1,68164	-53,3928	
-2,01689	0,179535	-13,1336	3,384247	-2,16819	20,84436	-2,4965	-49,054	
-2,37521	-0,26279	-14,7343	2,924103	-0,58255	20,40088	-7,56164	19,74686	
-2,37337	-2,99058	-15,1944	1,88504	-0,81061	20,58493	-11,4481	16,95291	

Table A.33 Wrist extension/flexion of S1 while playing to the one hand mode of the flight simulator (second run)

-5,42572	8,284228	19,38202	18,18274	-35,3401	-2,29141	-8,95718	-12,4799	-0,86685
-5,42572	8,423944	8,467884	13,50346	-33,9899	-2,76242	-5,7959	-7,14053	-0,86926
-5,42572	8,598574	1,570873	-12,4589	-16,853	-3,41214	-3,6051	-0,86276	-1,90314
-5,36432	8,75386	0,236654	-15,8068	-5,25858	-3,96783	3,344427	-3,13599	-1,32492
-5,36432	8,763697	0,064049	-16,7205	-1,86633	-4,29507	6,781416	17,70472	-1,3895
-5,36432	8,799126	0,283932	-20,4511	-1,61847	-11,6798	8,319738	17,77894	-1,40723
-5,11993	8,839395	-0,58969	-22,4088	-2,66315	-9,54825	7,588381	15,46947	1,128909
-4,85806	7,67275	-7,56119	-23,0158	-2,80963	-8,51413	4,195849	-1,41486	4,370109
-4,79172	8,696596	-7,22583	-23,0648	-3,94351	-8,27924	2,466882	-3,29083	2,471358
-4,68527	12,7764	-5,65756	-22,5208	-8,17807	-8,23187	1,671908	-3,45886	1,040304
-4,52411	14,98303	22,33959	-22,4962	-10,9702	-8,21335	1,618363	-2,92606	-1,17545
-4,31586	14,94576	29,50834	-22,3634	-19,0563	-8,44455	4,736086	-3,37833	-1,03363
-4,60983	14,92611	30,26498	-22,0924	-29,8863	-8,57153	3,710602	-4,66879	-1,84653
-4,66763	15,06175	30,8612	-22,2826	-29,5321	-8,74136	-0,81888	-3,44626	-1,45874
-4,96768	14,99402	29,8197	-22,3135	-21,6984	-8,94507	-0,04462	-5,2518	-1,26657
-4,8197	15,07462	25,23521	-22,4456	-9,43796	-9,02725	5,854728	-4,01654	1,458583
-4,70892	18,04334	16,82378	-22,5955	-19,008	-8,793	-1,22434	-5,14063	2,467567
-4,5502	26,12602	9,030885	-22,6912	-19,5936	-6,85043	-9,57166	-5,90427	
-4,53238	28,97272	4,428791	-23,1146	-4,01813	-6,00961	-13,8093	-4,40311	
-4,19196	29,13293	1,880588	-23,3968	-17,5436	-5,69009	-13,5673	-4,53021	
-3,84921	29,66617	0,90667	-24,4917	-19,3914	-5,3179	-12,9616	-4,51755	
-3,19916	29,81024	0,129904	-25,5478	-21,4783	-5,30219	-14,3058	-4,25574	
-3,13117	30,04225	-2,05466	-25,7257	-23,1056	-5,1394	-14,4066	-3,48843	
-3,76578	31,95122	-3,29608	-23,5984	-24,3392	-4,97363	-6,61609	-2,92877	
-5,42847	33,78512	-5,70871	-28,6308	-24,9307	-5,05216	8,27928	-2,59827	
-6,3118	33,71463	-7,38937	-34,2783	-23,6701	-4,82501	8,408719	-1,90207	
-6,51648	34,84468	-7,90363	-36,304	-23,0026	-4,97446	7,978005	-1,45953	
-6,98615	35,73242	-8,04718	-37,4225	-23,4245	-4,99207	7,420047	-2,10355	
-7,64032	36,43452	-8,0513	-37,6067	-23,1151	-3,68503	8,138847	-2,1572	
-8,27045	37,56665	-7,91773	-37,4325	-19,672	5,719342	6,764792	-4,31717	
-8,35922	37,39445	-7,82257	-37,3096	-19,1398	15,68079	5,929503	-5,11005	
-7,69293	37,07693	-7,62524	-38,4825	-19,3383	17,50027	4,822748	-5,31332	
-1,51871	36,87444	-7,69821	-40,2036	-19,225	19,01861	4,174799	-5,36362	
0,158807	36,51623	-7,72464	-42,2096	-19,3905	5,447258	2,464556	-5,67331	
1,927445	36,38034	-7,57559	-42,0978	-19,6105	-5,16922	-5,49152	-6,01798	
4,034339	37,13413	-7,67789	-41,9583	-18,3508	-8,39197	-12,9978	-6,07584	
5,364899	38,07269	9,53145	-41,9187	-11,8575	-12,2169	-13,1068	-6,05545	
5,982657	38,41447	22,18789	-41,6722	-5,25125	-10,3858	-12,5815	-5,51013	
6,530797	38,496	23,2369	-40,5444	-3,58975	-8,76248	-14,0644	-1,1619	
7,68183	30,57284	20,44423	-38,8535	-1,98502	-8,6171	-13,705	0,340723	

Table A.34 Wrist radial/ulnar deviation of S1 while playing to the one hand mode of the flight simulator (second run)

Figure 5.35

10,70598	-23,2845	39,09801	-53,054	26,1996	39,80573	-51,4508
8,833117	-3,90213	38,99205	-54,2172	34,15104	27,63581	-51,2093
8,833117	8,536622	38,43004	-53,5079	35,21098	6,588531	-50,997
6,018533	11,79366	14,65751	-53,0734	35,48076	-20,7955	-46,6086
6,018533	13,45388	-21,4097	-36,9637	35,49002	-27,0262	-10,583
1,44777	23,89965	-28,5753	3,433744	35,51101	-28,7715	2,900117
-26,3546	29,40821	-30,0114	11,46482	35,13647	-37,7623	17,60333
-4,98157	34,22605	-33,891	17,44124	34,39457	-46,2051	22,49966
15,67398	35,72849	-47,5068	22,78315	12,63267	-48,6571	23,45998
-14,3603	37,87247	-52,6484	26,41781	-23,7253	-50,5223	25,2434
9,946193	30,78909	-53,1077	26,758	-25,8114	-49,1577	26,48483
0,103313	-13,8893	-52,3096	26,26517	-25,4363	-21,501	26,72804
-1,29846	-22,8456	-45,633	18,44309	-24,3238	13,46705	26,5332
13,60016	-31,377	-28,3892	19,62257	-23,961	21,93032	26,23189
-5,72769	-35,9092	-6,991	34,09599	-22,5637	26,62647	23,8913
24,35923	-38,3673	5,828472	37,13864	-22,1177	25,86863	11,62413
11,02402	-38,6133	30,46404	37,15607	-22,6437	24,56709	11,82815
0,68581	-37,2819	37,31685	32,6424	-27,6077	24,1783	12,34463
-3,36798	-16,2351	38,37851	5,046897	-27,7512	7,145031	12,71322
-2,21018	-13,263	37,58919	-25,5091	-26,1661	-2,31064	12,79079
-1,78873	-14,7545	6,868727	-25,1826	-24,6455	-0,61194	5,182144
-2,9707	-16,0174	-15,6596	-24,3712	-23,6229	1,329916	4,221141
-4,03668	-15,4055	-19,4889	-23,0295	-22,6925	8,987321	2,036398
-3,82382	-14,5428	-18,0566	-19,4778	-21,2284	13,09237	2,393783
-3,49921	-14,3794	-15,4951	0,501516	-19,0178	19,43104	2,744236
-2,3876	-14,3663	0,374356	3,894173	-18,7276	17,69123	2,921175
-1,78168	-14,1413	18,67524	3,553068	-18,5596	22,37971	-1,80966
-1,79553	-13,9323	21,47245	-10,9772	-18,3895	23,63563	-17,6581
-2,00314	-13,7948	12,9968	-24,619	-17,7954	24,62535	-25,7468
-3,85352	-13,6704	10,30801	-33,1832	-16,3368	24,58032	-41,5371
-12,4268	-13,7097	10,29073	-29,6478	5,52094	24,30264	-42,8652
-24,5513	-13,6065	30,90563	-25,5174	31,23993	24,0429	-42,2776
-27,4469	14,37698	32,63372	-30,0404	36,62922	21,9591	-41,3466
-27,6081	35,21232	32,00949	-40,0417	37,58292	-6,90784	-41,5311
-27,3545	37,73847	26,32789	-36,8062	38,0088	-19,217	-41,4345
-28,2643	38,67614	17,44783	-33,0399	40,78822	-27,2789	-28,2854
-36,112	38,82088	-8,56863	-32,1501	40,72181	-46,0982	15,4406
-41,0715	38,33483	-26,1441	-34,0806	40,67076	-49,3585	25,80106
-41,4675	37,80517	-31,0531	-33,1427	40,51073	-51,4034	35,26056
-40,8909	37,82573	-42,3015	-2,62448	40,44026	-51,8827	37,45263

37,84449	-38,1168	-51,5187	34,35946	-36,5856	-25,3461
37,69786	-47,3014	-28,3254	35,71193	-47,0804	-31,7644
37,14478	-47,6971	-0,67419	35,87367	-50,0367	-25,7168
36,55223	-47,7773	21,54989	35,47147	-51,688	-33,64
35,80618	-47,7292	24,86776	-5,6983	-51,5451	-32,7079
36,44063	-47,5694	26,78953	-29,1754	-49,9068	-30,5367
36,55218	-47,1683	28,32586	-32,4765	-33,4757	-31,4081
28,3195	-46,6531	29,4869	-32,3166	-2,84946	-29,0471
-20,9694	-46,5731	27,32003	-31,5428	11,76342	-27,5325
-28,2921	-46,2578	24,19102	-31,083	20,28812	-30,4863
-33,4091	-46,1576	23,40117	-29,0443	20,26217	-30,5322
-35,1633	-46,0317	23,45332	-26,3107	16,51048	-31,0164
-35,5295	-45,8743	23,80824	-21,689	16,04921	-31,003
-35,4228	-10,4793	21,05097	-18,571	10,57009	
-33,9478	22,82203	15,09677	-12,0424	4,491662	
-33,5041	24,85546	-17,6031	2,671721	5,109715	
-32,3638	24,84451	-19,4965	6,093188	5,268874	
-22,5938	24,08436	-19,493	6,81566	5,280864	
-1,04623	23,77415	-17,9244	-24,9182	5,434713	
-0,64597	23,02502	-2,87674	-27,5824	16,08834	
-10,6762	22,66816	0,364624	-25,6621	23,45546	
-21,5917	22,47012	1,577933	-25,4108	25,34652	
-20,9524	22,25429	1,416415	-25,1125	26,02348	
-19,5676	22,4969	-19,6891	-24,8256	25,66239	
-19,3327	27,19697	-33,2948	-24,5588	24,19569	
-19,3916	28,14831	-31,5381	-9,1825	21,51412	
-13,0191	27,94165	-30,697	6,265235	21,28639	
0,342724	27,4893	-30,7432	19,94848	21,13157	
12,11035	27,77904	-31,9636	26,50038	20,19194	
16,79046	27,72366	-37,0031	32,83189	0,356361	
29,60829	9,56487	-36,0734	33,15443	5,268131	
34,42658	-27,9802	-35,9009	32,60148	3,701691	
36,52315	-50,6912	-36,9646	32,44137	4,362072	
37,21457	-52,9777	-36,0445	33,54882	3,338148	
36,29954	-53,161	-21,1725	34,22372	2,330451	
35,53336	-52,7094	26,61948	33,66232	2,827686	
35,4913	-52,3975	31,44163	33,15671	3,125157	
35,41345	-52,0431	33,78343	3,470394	0,827597	
18,26454	-51,6561	34,45902	-19,6365	-2,23474	
-25,7409	-51,5442	34,40814	-20,246	-17,3035	

Table A.35 Wrist radial/ulnar deviation of S1 while playing to the deviation mode of the ski game

Figure 5.36

-0,16275	-23,6843	38,77559	-52,7395	53,859	36,90583	-66,2921
-0,16275	-30,5478	38,19848	-54,9208	53,80075	18,85714	-66,6178
-0,16275	-50,3671	37,11265	-55,9134	51,70354	-41,919	-66,4338
-0,07907	-61,1091	35,01902	-55,2012	50,87617	-44,5615	-56,9009
-0,07907	-62,4365	2,98682	-48,2722	49,50636	-47,4817	10,24937
-0,07907	-60,4201	-17,4794	-22,8171	48,56208	-52,464	29,3614
1,325899	-55,3993	-59,2632	30,05363	47,92665	-55,6352	36,15396
0,631437	-30,3221	-82,6706	60,94668	45,09267	-51,3612	40,50116
1,848691	-5,62744	-117,754	60,98813	35,67496	-51,6377	40,04078
-8,12515	-5,99268	-119,189	55,81799	-23,7225	-51,22	41,27814
0,295173	-15,3792	-108,884	56,70646	-30,7878	-42,9264	40,77701
28,67435	-17,6595	-94,3065	55,55711	-42,226	-6,70987	38,50622
36,07518	-19,1598	-96,2178	55,00787	-40,7029	12,3856	36,81147
42,73252	-24,5821	-92,2643	49,86458	-40,4201	25,67586	24,12613
43,27246	-28,2965	-57,9248	48,127	-43,2818	33,64237	-19,8992
18,99302	-29,8941	44,77741	48,80564	-35,2626	32,02648	-12,5421
-9,89996	-30,0503	22,82663	45,85149	-21,6545	28,68251	-11,7292
-13,7602	-29,3398	32,72249	30,99899	-8,44919	25,0647	-7,15002
-14,146	-28,4325	40,98207	13,45106	-3,82895	23,89188	-4,67685
-13,7539	-28,2471	44,00063	-18,2793	-11,4515	-1,61285	-2,16754
-12,6986	-26,4605	42,02606	-22,501	-14,6717	-13,9645	-5,49875
-11,2813	0,607693	41,61716	-22,116	-15,4204	-7,90872	-9,76297
-9,53583	-1,42233	39,82698	-18,4424	-15,6976	-5,42819	-10,0085
-8,50397	-3,13821	38,89581	-11,5688	-15,7776	1,782389	-9,89673
-7,92377	-4,02805	36,39132	15,54551	-14,3821	9,041069	-9,20364
-7,33319	-11,5281	33,13964	10,76176	-13,1068	11,67238	-9,62863
-6,98761	-14,5921	24,69519	5,596019	-14,544	9,75818	-12,6457
-6,88388	-13,2385	25,42764	-0,90817	-16,1185	16,12967	-17,8418
-6,6687	-11,0877	26,17201	-35,7159	-16,7933	19,79656	-23,6279
-6,54096	-10,5534	34,71473	-40,3329	-16,9059	16,04138	-26,3979
-17,8105	-10,7886	32,45062	-43,0558	-0,13443	15,27456	-26,9955
-27,5031	-9,61447	30,82253	-42,7632	36,04343	15,29912	-26,3029
-27,1335	3,214192	29,72533	-39,9775	47,06886	15,74787	-26,3544
-24,2529	15,36838	30,5515	-38,3776	45,76662	-16,2701	-25,1482
-19,2825	42,62961	30,87144	-38,3968	42,37968	-39,2383	-21,3876
-23,2614	46,71722	-2,49683	-38,1867	41,57373	-53,001	-9,69778
-27,9667	42,83775	-37,6792	-34,33	41,04855	-55,5061	43,10665
-25,5912	42,2772	-53,9029	-32,3135	38,0662	-57,9349	51,76587
-25,6804	41,20515	-66,9403	38,68922	36,07174	-57,8111	48,7125
-25,3501	39,18525	-55,0436	51,87169	36,84179	-66,1149	44,91518

39,99308	48,06387	-31,1815	43,85446	-44,0328	-0,03296
36,95494	2,911847	-23,9496	41,72305	-53,3334	0,441325
35,01505	-17,4176	8,662189	41,23263	-56,0458	-3,54752
34,91411	-42,4775	40,36018	34,76104	-50,6418	-2,5333
33,95544	-50,9796	63,30203	-19,2655	-40,3957	1,088112
29,53084	-56,1866	67,31239	-45,4464	-39,1312	-1,05228
30,11745	-63,3584	64,02177	-40,0232	-38,593	
-1,33853	-59,9657	58,69449	-32,2528	-6,79358	
-23,6024	-57,1924	58,40459	-31,5852	28,49608	
-33,3349	-51,9498	55,71378	-28,8988	20,46478	
-33,6865	15,96159	55,1094	-26,9978	14,04852	
-33,0955	41,6245	53,20643	-23,8546	12,09923	
-31,5052	43,21235	46,2299	-21,9594	10,23355	
-29,6309	35,60503	41,90743	-20,7368	10,04968	
-29,4458	34,39663	36,01435	-20,3586	-14,3591	
-27,5418	32,79745	-8,84427	-20,4604	-12,3006	
-28,3469	30,7081	5,156883	-20,4663	-9,73056	
-27,5716	29,23602	7,332394	-20,4669	-1,82987	
-26,4986	28,75898	11,68416	-21,3019	-0,68317	
-19,4184	28,76051	12,24324	-21,9185	-0,30463	
-11,2006	25,65128	13,71384	-22,0111	0,760094	
-5,91962	28,76142	14,04799	-22,0787	10,25064	
-5,12021	35,72782	12,22783	-20,1695	24,15353	
-4,0827	35,60376	7,521734	-18,9459	25,33458	
-5,19971	31,09274	-21,2941	-19,9044	23,94789	
-8,21137	25,03878	-19,5226	-18,7835	22,52989	
-8,47546	25,83329	-32,2123	11,71339	20,74487	
-6,37906	27,3397	-33,4234	44,21938	5,646461	
-6,07462	29,19001	-26,2569	45,11115	-40,9174	
0,049068	29,14342	-29,0816	41,8563	-10,9893	
14,32701	8,257868	-28,9998	36,73225	-15,3474	
20,65883	-31,0122	-26,2733	34,71153	6,878727	
22,36028	-41,3952	-23,2226	34,23642	4,498957	
28,45962	-49,1335	-5,50519	33,64298	3,433918	
51,62167	-45,4825	42,23177	34,14101	-9,7641	
55,5997	-38,001	49,93546	37,50131	-13,3428	
46,90809	-39,1063	52,59754	36,97495	-8,07199	
40,20538	-38,726	53,41574	23,04732	-2,88193	
37,17994	-38	48,93354	-17,9493	0,306266	
23,80626	-38,4278	43,95356	-29,7416	-3,97348	

Table A.36 Wrist extension/flexion of S1 while playing to the extension/flexion mode of the ski game

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