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1 Introduction

1.1 Available hardware

ANG-med is an instrumented rollator based on a commercially available walker with 4 wheels designed at INRIA. It has

- two servo-motors that actuate the existing brakes
- two encoder in the rear wheels
- 6 infrared unidirectional distance sensor. Four are mounted in front of the rollator, 2 are looking backward and are mounted on pan/tilt heads that allows to modify their direction of measurement
- one 3D accelerometer/gyrometer
- a GPS
- two infrared receivers that allow communication with a TV remote
- two 23Ah lithium-ion batteries
- a 2-lines 20 characters LCD display
- 6 leds (2 red, 2 green, 2 yellow)
- a on-of switch button that will be called the *main switch*
- a multi-position switch
- a general on-off switch
- a computer (fit-pc 2) that may be cooled by a fan

1.2 The walker reference frame

When the walker is used for the first time it will define a reference frame i.e an origin and a direction for the x, y axis. The origin O of the frame is defined as the middle point on the common axis of the rear wheels, the y direction is defined by the forward direction of the walker and the x axis is perpendicular to the walker axis, directed along the right of the walker (figure 1). Any subsequent motion of the walker will be defined with

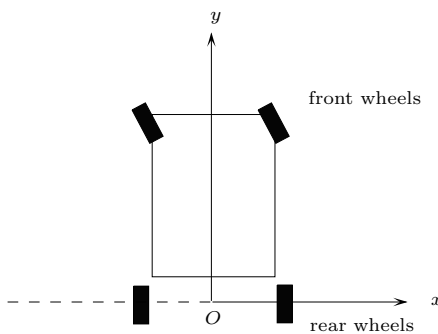


Figure 1: The reference frame used by the walker

respect to this initial frame.

2 Exercises

ANG-med is basically designed to execute *exercises* that may be defined as a clinical act whose purpose is to monitor the behavior of a subject and provide an objective assessment of this behavior. This monitoring may be *passive* (the walker just record and report the behavior) or *active* (the walker is part of a rehabilitation process and report data about this process). The report provided by ANG-med are basically of two types:

- *synthetic indicators*: they summarize with a few numbers the overall behavior of the subject after an exercise is completed or during the execution of the exercise
- *full record*: ANG-med may produce record files (that may be quite huge) during the execution of an exercise. These records are intended to be processed by specific software to provide a more detailed analysis of the exercise than the one provided by the indicators

ANG-med is basically designed to work under three modes:

- *stand-alone*: this mode does not require any connection between the fit-pc and the outside world. In this mode ANG-med will receive orders from the available interface that will be described later on
- *connected*: in this mode ANG-med has to be connected to internet through a wifi connection. In this mode it may receive orders from a tablet or a PC that will be called the *control* in this document
- *physically connected*: a caregiver may connect a screen, a mouse and a keyboard to the fit-pc in order to use it as a workstation

The stand-alone mode is the simplest one: it allows to use almost immediately ANG-med as the setup time is reduced to a minimum. The drawbacks of this mode are that ANG-med is able to execute only a set of predefined exercises (whose list is however quite extensive) and that in this mode ANG-med may provide information only through a LCD display. Hence it will only be possible to report synthetic indicators.

In the connected mode the overall behavior of ANG-med may be controlled from the tablet. This allows one, for example, to design or download a specific exercise, to run a predefined exercise but to modify its behavior according to the measurements provided by the sensors from ANG-med and to download efficiently the indicators . . . The weaknesses of this mode is that a wifi failure may prohibit the execution of the exercise (although the firmware in ANG-med has be designed to always try to preserve the safety of the subject) and that the execution of an exercise through the wifi connection will be less efficient from a real time viewpoint because of the communication delays.

Note that the connected mode can be used intermittently. For example ANG-med may be started in a connected mode (e.g. to download a specific exercise) then be run in the stand alone mode and again be switched to a connected mode after the completion of a serie of exercises in order to get efficiently the exercise reports (e.g. at the end of the day). Note also that for prefined exercises a failure of the connected mode (e.g. because of a loss of wifi connection) will usually not forfeit the exercise. On the other hand for exercises that are fully managed by the control a loss of connection may compromise the result of the exercises.

Important note: before running any exercise with a new subject that may use the walker extensively it is essential to run a few preliminary steps that are described in the section 11.

3 Interface and hardware

ANG-med has several interface means. In the stand-alone mode the interface elements are on the *LCD box* and through the remote.

3.1 LCD box

The LCD box is located in the box close to the seat of the walker. It include the LCD display, the main switch, the leds and the multi-position switch (figure 2).

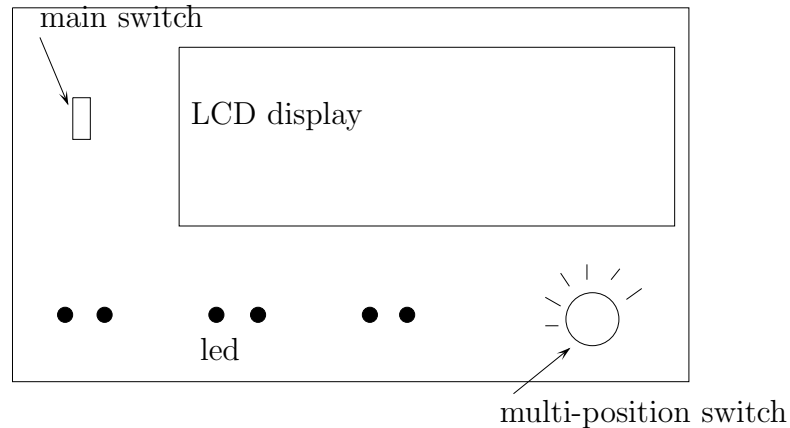


Figure 2: The LCD box

3.2 Remote

3.2.1 Using the remote

The IR receivers of ANG-med are located at the front and at the rear of the LCD box. To use the remote you must direct the remote toward one of this receiver. A red led will light if the remote emit a signal.

3.2.2 Changing the battery of the remote

The remote may be used for a long time but still its batteries may have to be changed at some point. After changing the batteries it is necessary to reinitialize the remote:

- press the "SETUP" button of the remote until the red led is lighted continuously
- introduce the code 0002 with the numerical key (when you press a key the led must light off temporarily, when hitting the 4th element of the code it must switch off)

3.3 Batteries

3.3.1 Presentation

ANG-med has two 23Ah batteries that are located at the bottom of the walker. In between these batteries there is small black box with a green led and the *main power switch*. On top of each battery is a switch: **you must never touch this switch!** Close to this switch there is a LCD display that provides the level of battery charge (a number between 0 and 100) and a bar indicator In front of the battery you have a set of connectors: USB one and two power connectors that are labeled *charge* and *12V*.

3.3.2 Charging the batteries

To charge the batteries you must:

- set the main power switch to the off position: **never charge the batteries with the main power switch in the ON position!**
- unplug the two power connectors denoted *12V*. **Never charge the batteries with the 12V connectors still connected to the batteries**
- plug the two power connectors denoted *charge* to the 2 power supply provided with **ANG-med** . The LCD display on the battery should light on and the bar indicator should move up and down. The charger will automatically shutdown when the battery are fully charged.

If the batteries are fully discharged it takes about 6 hours to be fully recharged.

3.3.3 Autonomy and low battery signal

Starting from a full battery charge it is expected that **ANG-med** may run in full mode for about 48 hours but this number depends upon the type of exercise that is run by the walker.

ANG-med monitor the battery voltage and will emit a signal toward the control through the communication if the battery voltage is low. If the voltage still decreases and get below a threshold, then **ANG-med** will automatically shutdown after saving all records of the current exercise. It is then necessary to recharge the batteries before being able to use **ANG-med** again.

3.4 The fit-pc computer

The on-board computer of **ANG-med** is a fit-pc. You may only see the front face (figure 3) of this computer. Of particular importance is the ON button of this computer which is located on the left of the front face (it's a tactile button). When used extensively the fit-pc box may become quite hot. A fan will automatically be

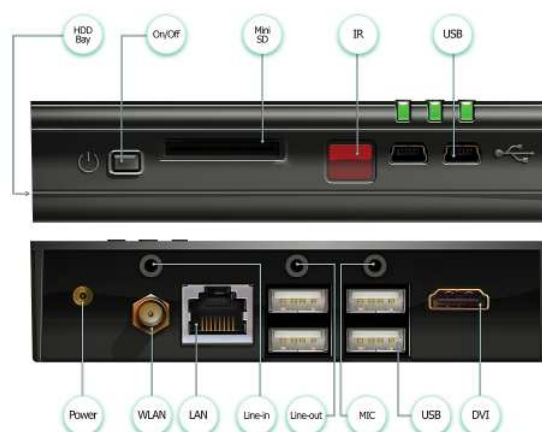


Figure 3: Front and rear face of the fit-pc

switched on if the temperature is too high and will be switched off if the temperature becomes lower than a threshold. The name of the fit-pc computer is indicated both on the PC and on the support box. The computer run an Ubuntu linux OS.

4 Subject, caregiver and mark ID

4.1 Subject ID

It may be necessary for some exercise to provide the ID of the subject performing the exercise and/or the ID of the caregiver that is managing the exercise. The purposes of having a subject ID is twofold:

- to associate ID and records so that caregivers can follow the evolution of a given subject over time
- defining a *profile* for each subject that store parameters for the walker that will allow it to perform in the most efficient way for assisting the subject

ANG-med maintains a list of known subject IDs together with their profiles. Any new tags that is presented to the walker will be considered as a subject tag unless it is recognized as a caregiver or mark tags (see next section)

We describe in this section how to provide physically these ID.

4.1.1 Providing ID with the walker

The walker is equipped with ashor range RFID reader (the range is about 10 cm) located in a gray box on the left side of the walker, close to the seat. Presenting a rfid tag to the reader will able to define the ID of the subject.

4.1.2 Providing ID with the control

to be described by INDES

4.2 Caregiver ID

ANG-med is provided with special RFID tags that are reserved for the caregivers. Such a tag will allow the caregiver to access most of the results of the exercise.

4.3 Mark ID

ANG-med is provided with a set of *mark tags* that will be dealt in a special way. First they will not be recognized as subject or caregiver tags and will not be stored in the system. They are basically provided to be used as special even (e.g. they will be put in specific place and their use will allow to determine that the walker was in this place).

5 Starting ANG-med

- if necessary unplug the batteries power connectors labeled *charge*
- plug in the battery power connectors labeled *12V*

- Before starting **ANG-med** you must decide what type of exercise you want it to run. A very frequently used exercise is the *dynamic walk exercise* that will be described later on. If this is the exercise you want to run set the main switch to the ON position. If you want to run another predefined exercise then put the main switch in the OFF position.
- put the main power switch in the ON position (a green led close to the main power switch should light on). Normally this switch also on the on-board computer (green leds on the fit should light on) but if this not the case just push the ON button of the fit-pc. It will take about 20 seconds before **ANG-med** is fully functional. When ready all the leds of the LCD box should light on for a few seconds, then get off. **ANG-med** firmware will automatically start when the computer is ready. The LCD display of **ANG-med** should also light on, then show the battery voltage for a few second and then will show **No exercise** if the main switch is on the OFF position or **Dynamic walk** if it is on the ON position. The fit-pc will normally automatically connect to the appropriate wifi LAN.

Note that:

- if you have started **ANG-med** with main switch in the OFF position but want to run the default *dynamic walk exercise* just put the main switch in the ON position
- if you have started **ANG-med** with main switch in the ON position but want to run another exercise than the default *dynamic walk exercise* just put the main switch in the OFF position and restart **ANG-med** (see section 8)

6 Closing ANG-med

- use the POWER remote key to switch off the fit-pc. If this does not happen just press the ON button of the fit-pc for a few seconds
- put the power switch in the OFF position

7 General use of the remote during exercise

The following remote key have a fixed role in the firmware:

- **POWER**: will stop the fit-pc computer
- **EXIT**: will stop the current exercise
- **EMPTY SCREEN**: this key is located below the POWER key, it will cancel the current exercise. If the exercise is in a repeat mode the same exercise will be started
- **DOUBLE SCREEN**: this key is the second black one starting from the left at the top of the remote. It will cancel the current exercise and restart the firmware

8 Starting and closing a predefined exercise

There may be up to 100 predefined exercises loaded in **ANG-med** . They are labeled from 0 to 99. When started with the main switch in the OFF position **ANG-med** will be waiting to receive orders either from the control (if in the connected mode) or from the remote (if in the stand alone mode). An order of special importance is the choice of the predefined exercise that will be run.

8.1 With the remote

To start an exercise you must see the message **No exercise** on the LCD display. If this is not the case put the main switch in the OFF position and use the **EXIT** remote key: the LCD display should show briefly the message **Final exit**. In this state to start an exercise with the remote you will have to provide the exercise number:

- use the numerical keys of the remote to provide the exercise number. When a numerical key is hit (say 4) the LCD display should show the message **E:4**. Note that it may happen that the remote believe that a key has been hit twice (in our example the LCD display will show **E:44**). To avoid that use only short pressure on the key. To cancel the sequence use the yellow key at the bottom of the remote and restart
- as soon as the LCD shows the right exercise number push the green key at the bottom of the remote: the exercise will start almost immediately and the LCD display should show on the first line the title of the exercise

To close an exercise use the **EXIT** remote key and in some cases you may have to use the **DOUBLE SCREEN** key. On a successful closing the LCD display should show briefly the message **Final exit** after what the led and LCD display should act as when starting **ANG-med** .

8.2 With the control

to be described by INDES

9 Subject position

9.1 Position indicator

ANG-med may use its backward looking distance sensors to evaluate the position of the subject with respect to the walker (too far, too close, correct). **ANG-med** will provide as measurement of the subject position an indicator between 0 and 100 where 0 means that the subject is too far, around 50 if it is in a correct position and around 100 if he/she is too close. This indicator is obtained by measuring the left/right leg distances to the walker. For that purpose it is necessary that the rear looking distance sensors may "see" the legs at all time. The direction of the sensor measurements are set by default in a mean position that will be valid for many subjects but may fail for some of them. Hence it is advised to run a calibration process for each user in order to obtain the best indicator estimation.

9.2 Subject position calibration

The calibration of the position measurement is performed by running the exercise called **pose calibration**, starting with the main switch in the OFF position. The calibration procedure uses the following steps:

- move the rear servos to the standard position. The raw values of the rear distance sensors are displayed on the LCD every second
- the subject moves in any position (too far, too close, correct). The caregiver looks at the distance information. In any of the above positions the raw values of the distance should be between 90 and 490. At any time of this step the subject or the caregiver has to provide the subject id tag to the RFID reader on **ANG-med** .
- if the distances are not correct the caregiver use the remote to change the orientation of the sensors. The remote key 1, 3 allows to rotate the left sensor around the vertical axis while 2, 5 allows the rotation

around the second axis. 7, 9 do the same thing for the right sensors around the vertical axis while 8, 0 change the second axis.

- after correcting the orientation of the 2 sensors to get correct measurement in all subject poses the caregiver push the GREEN button of the remote.
- the subject has to move first to the correct position. When this position is reached the caregiver push the GREEN button of the remote. The walker will measure the distances for 5 seconds and present the mean distance. If they are correct the caregiver push the GREEN button
- the process is repeated for the too close and too far positions
- after having obtained the distance for the 3 positions (too far, correct, too close) the caregiver validates the result which is stored

At any time the calibration process may be canceled by using the EXIT button of the remote.

Important notes:

- it is essential to provide a subject ID during this exercise so that the calibration result will be attributed to a known subject and stored in its profile
- this exercise has to be run only once. In any exercise where the position of the subject has to be measured providing the user ID will allow the rear looking distance sensors in the best position measurement.
- running this exercise allows to register the subject as a valid user.

10 Subject pressure on the handles

ANG-med may use the accelerometer data to evaluate how much pressure is put on the handles by the subject in the forward/backward direction as well as on the left/right side. But for this calculation it is necessary to calibrate the measurements.

10.1 Calibration

The calibration process of the handle is performed by running the exercise called **handles calibration** that is described in the exercise section. Basically this process consists in measurements performed without any subject, with the subject fully leaning on the walker in the forward direction, then on the left and right side of the walker.

Important notes:

- it is essential to provide a subject ID during this exercise so that the calibration result will be attributed to a known subject and stored in his profile
- this exercise has to be run only once. Any exercise where the pressure of the subject has to be measured requires that this exercise has be run beforehand
- this calibration is valid only for a given slope of the ground. We advise to perform it on a flat ground
- running this exercise allows to register the subject as a valid user.

10.2 Pressure indicators

When calibrated it is possible to obtain a measurement of the amount of pressure put on the handles during an exercise. This will result in 3 indicators that range between 0 and 100:

- forward/backward pressure: that allow to determine how much support is the subject asking from the walker. An indicator of 0 means that the subject is just pushing the walker while an indicator of 100 will mean that the subject is heavily leaning on the walker
- left/right pressure: that allow to determine if the subject is putting different pressure on the handles when he is on the left/right leg support phase during a walking

11 Introducing a new subject to ANG-med

In this section we explain what should be done when a new subject will have to use the walker so that ANG-med may be used the most efficiently.

11.1 Registering the subject ID

The simplest way to register a new subject is to use the exercise called `id creation`. However running this exercise is not compulsory as running other exercises may lead to an automatic registration of the subject. If the subject is not registered all the exercise results will be attributed to a fictive subject called `anonymous`. But as this id may be used for different subjects we advise to run an id registration procedure before executing any medical exercise.

11.2 Calibration of the subject position

This will allow to obtain the best measurement of the position of the subject with respect to the walker. Running this calibration is explained in the section 9.2. Presenting a subject ID to the walker during this calibration allows to register automatically the subject.

11.3 Calibration of the pressure on the handles

This will allow to obtain the measurement of the pressure exerted by the subject on the handles of the walker. Running this calibration is explained in the section 10.1. Presenting a subject ID to the walker during this calibration allows to register automatically the subject.

12 Indicators

Indicators are synthetic assessments of the subject functional status. There are specific indicators for each exercise. Note that each indicator has an access level i.e. that some of them are provided only to a caregiver and not to a subject.

12.1 Indicator and their means

- *date completed*: the date when the exercise has been completed. This date is given in the format `day-month-year_hour-minute-second`
- *date started*: the date when the exercise has been started. This date is given in the format `day-month-year_hour-minute-second`

- *distance_signal max_amplitude*: the maximal value of a distance signal
- *distance_signal max_duration*: the duration in seconds of the phase during which the distance signal was around the maximum
- *distance_signal mean_amplitude* : the mean amplitude of the distance signal
- *distance_signal mean_duration*: the mean duration of the distance signal
- *distance_signal min_amplitude* : the minimal value of the distance signal
- *distance_signal stat_level* : the mean, minimum and maximum of the distance signal
- *distance_signal stat_down_duration* : the duration in seconds of the phase during which the distance signal was around the minimum
- *distance_signal stat_up_duration* : the duration in seconds of the phase during which the distance signal was around the maximum
- *lateral deviation*: this indicator is valid for exercise where the subject has to walk along a straight line. It provides the minimum and maximal values of the x coordinate of the walker during the exercise
- *max_angular_speed*: the maximum of the rotational speed along the z axis (rad/s)
- *max_front_distance*: the maximal values of the 4 forward looking distance sensors
- *max_speed*: the maximal velocity of the center of the walker (in cm/s)
- *mean_angular_speed*: the mean value of the rotational speed along the z axis (rad/s)
- *mean_front_distance*: the mean values of the 4 forward looking distance sensors
- *mean_speed*: the mean value of the velocity of the center of the walker (in cm/s)
- *mean_subject_handles_pressure*: the mean values of the forward/backward, left, right pressures on the handles (see section 10)
- *mean_subject_position*: the mean value of the position indicator during the exercise (see section 9)
- *min_front_distance*: the minimal values of the 4 forward looking distance sensors
- *number of exercises*: the number of time the exercise has been performed
- *record number*: the number of records stored by the walker.
- *time*: the duration of the exercise (in seconds)
- *time of no motion*: the duration in seconds of the time during the walker has not moved during an exercise
- *travel*: the euclidian distance travelled by the center of the walker

12.2 Getting the indicators in the stand-alone mode

Start **ANG-med** with main switch in the OFF position. As soon as you see the message **Waiting** on the LCD press the remote key with a window and line (top left black button). The walker will display the starting date of the exercise (in the format day-month-year_hour-min-sec) for which it has an indicator file, starting from the most recent one. From here you may:

- validate that this is the exercise that you are interested in by using the **GREEN** remote key
- go on to the previous exercise by using the **YELLOW** remote key
- move faster to older exercise by using the **VOL-** remote key
- move back quickly to more recent exercise by using the **VOL+** remote key

When you have found the exercise of interest you may:

- display in sequence each data of the indicator file by using the **GREEN** remote key. Each use of the key will allow you to get the next valid data. When all data have been read the display will restart from the beginning
- stop getting the indicator data and get back to the list of available indicator, starting from the most recent one by using the **YELLOW** remote key
- skip 2 indicators by using the **VOL+** remote key

At any time in this mode you may use the **POWER** or **EXIT** remote key to exit this mode. If in this mode for more than 5 minutes without using a remote key then the walker will automatically exit from this mode.

12.3 Getting the indicators in the connected mode

to be described by INDES

13 Data confidentiality

ANG-med is designed to protect the privacy of subjects even when providing indicators. Full medical indicators are provided only to fully identified caregivers while access to the full records is not possible directly even for caregivers. Compromised access to the fit-pc may allow to get the values of the indicators but not of the full records that are crypted.

14 Predefined exercises

14.1 Dynamic walk (default exercise), number:0

14.1.1 Purpose

In this exercise we just record the followed trajectory and the travelled distance of the walker during the day. The purpose is to determine the level of activity of the subject. The exercise description is valid for the stand alone mode.

14.1.2 Completion and cancellation

The exercise is considered to be completed:

- at 8pm
- if the GREEN or EXIT remote key are pushed

The exercise can be cancelled by using the EMPTY SCREEN key

14.1.3 Marks

We may store also "marks" on the trajectory that indicate that the walker is in a specific place. In this mode marks are indicated by presenting a rfid tag or hitting one of the numerical key of the remote.

14.1.4 Indicators

After a successful completion of this exercise the traveled distances and the duration of the exercise will be displayed on the LCD for 5 seconds

Beside the travelled distance and the duration the following indicators are sent to the control:

- max speed
- max angular speed
- number of record written in the record file
- date when the exercise started
- date when the exercise completed
- total time of no motion of the walker
- mean value of the position indicator
- mean values of the handle pressures (provided that the pressure have been calibrated for the subject other the indicator values is -1)

14.1.5 Description in connected mode

to be described by INDES

14.1.6 Further analysis

An external software (not yet ready) may then be used to determine the subject trajectory in a given building

14.2 Correct position, number:1

14.2.1 Purpose

position!correct

The purpose of this exercise is to monitor the position of the subject relative to the walker

14.2.2 Operating mode

The subject is put behind the walker and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

The red led will be lighted if the subject is too far from the walker or way to close, the yellow leds will light is he is too close while the green led will light if he is in a correct position.

The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

14.2.3 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.2.4 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- mean value of the position indicator

14.3 Medical 10m walk, number:2

14.3.1 Purpose

The purpose of this exercise is to evaluate the walking ability of the subject when he walks along a straight line.

14.3.2 Operating mode

The subject is put in a given location behind the walker with sufficient free space in front of him for walking at least 10m in straight line. In this location he has to stand still and the exercise starts if:

- the caregiver hit the green remote key when the subject is ready
- the subject present a rfid tag

The subject then has to move along a straight line, if possible for at least 10m at a normal walking pace. The exercise is completed when:

- the caregiver press the EXIT remote key
- or the traveled distance is larger than 16m
- or the time duration is larger than 25 seconds
- or the walker does not move for more than 5 seconds

14.3.3 Repeat

This exercise is in the repeat mode so as soon as it has been started once it will restart on completion

14.3.4 Cancellation and exit

It is possible to cancel the current exercise by using the EMPTY SCREEN key of the remote

To exit from this exercise to move to another one you may use the DOUBLE SCREEN remote key (or a specific row order)

14.3.5 Indicators

During this exercise the walker records very accurately the trajectory of the walker. At the completion of the exercise the walker provides through row order as indicators of the walking abilities:

- the duration of the exercise,
- the travelled distance,
- the maximal speed
- the min/max of the lateral deviation
- the name of the record file.
- the number of failed and successful exercise

Further analysis of the recorded data will require an external software (not yet designed).

14.4 Time Up and Go (TUG), number:3

14.4.1 Purpose

The purpose of this exercise is to evaluate the walking ability of the subject. He will sit in a chair, stand up by using the walker, move along a straight line for 3 meters, make a turn-around and come back to sit again in the chair with the walker in front of him. During this exercise the walker records very accurately the trajectory of the walker.

14.4.2 Operating mode

The exercise starts if:

- the caregiver hit the green remote key when the subject is ready
- the subject present a rfid tag

14.4.3 Completion and cancellation

The exercise will automatically complete if:

- the caregiver press the EXIT remote key
- or the traveled distance is larger than 9m
- or the time duration is larger than 25 seconds
- or the walker does not move for more than 5 seconds

This exercise is in the repeat mode so as soon as it has been started once it will restart on completion except on using the DOUBLE SCREEN remote key or a row order

14.4.4 Indicators

At the completion of the exercise the walker provides through rowe as indicators of the walking abilities the duration of the exercise, the travelled distance, the maximal speed deviation and the name of the record file. Further analysis of the recorded data will require an external software (not yet designed).

14.5 ID creation, number:4

14.5.1 Purpose

The purpose of this exercise is just to create a new subject ID during the blocking start. After completion the system will know that the presented tag correspond to a subject.

14.5.2 Completion

This exercise completes as soon as a RFIF tag is presented

14.6 Position calibration, number:5

14.6.1 Purpose

The purpose of this exercise is to run the position calibration for a new subject i.e. orienting the rear looking distance sensors so that they will allow to determine if the subject is too far, too close or correctly positioned with respect to the walker. In this exercise the subject has to present its ID when in the blocking start loop.

The caregiver has to ask the subject to move in various position (close, far and correct). The LCD display shows the distance measurements of the sensors. The direction of the left rear sensor may be adjusted using the remote key 1,3 (vertical rotation) and 2,5 while the right sensor direction are adjusted using the 7,9 and 0,8 keys. In this step the caregiver has to ensure that in all position the reading of the sensors is in the range 90-490. When the readings are ok the caregiver pushes the green remote key The subject will have then to move correct, too close, too far position. When the subject is ready the caregiver pushes the green key and the walker will record the data for the current position for 5 seconds (i.e the subject has to stay in this position for seconds without moving). After the completion of the position the caregiver will push the green key of the remote to validate.

14.6.2 Completion and cancellation

You may cancel at any time the exercise by using the EXIT remote key. The calibration procedure will be run in the main loop and this exercise will be considered to be completed as soon as the calibration procedure is completed

14.7 Handles calibration, number:6

14.7.1 Purpose

The purpose of this exercise is to run the handles calibration procedure for a new subject. After this calibration it will be possible to determine the level of support requested by the subject: how much he leans on the walker in all direction: forward/backward, left/right.

14.7.2 Operating mode

To start this exercise you need to have the main button in the OFF position. The first step of this exercise is to provide the subject ID by showing a RFID tag to the walker. As soon as it is done the walker will give you 3s second to let the walker be free of any user and stopped. Then the walker will proceed with measurement for a

few seconds. When it has finished it will show the message "ready to calibrate" on the LCD display. Afterward we will start a sequence where the subject will have 5 seconds to move in a given position, stay in this position for a few seconds and then move to the next position. The position sequence will be:

- fully lean on the walker with its full weight on both handles
- lean with its full weight on the left handle
- lean with its full weight on the right handle

The first step is essential as there must be a significant difference in the measurement when the walker is free and when the subject is leaning with its full weight on the handles. If this is not the case this sequence will be repeated. Note that the calibration is valid only for a given slope of the ground. It is therefore better to run this exercise when the walker is on a flat ground.

14.7.3 Completion and cancellation

You may cancel the exercise by using the EXIT remote key. The calibration procedure will be run in the main loop and this exercise will be considered to be completed as soon as the calibration procedure is completed

14.8 Maze, number:7

14.8.1 Purpose

The objective of this exercise is to evaluate the ability of the subject to manipulate the walker in a complex environment. Typically the subject will be put in a room with several obstacles and will have to move among these obstacles to reach a given location.

14.8.2 Starting and cancelling the exercise

The exercise starts when the caregiver pushes the GREEN key of the remote and will be considered to be completed when it pushes the EXIT key.

This exercise is in the repeat mode so as soon as it has been started once it will restart on completion except on using the DOUBLE SCREEN remote key or a rowe order

14.8.3 Managing different mazes

It is possible that different mazes may be tested with various complexity. It is suggested that the caregiver uses the mark tags to identify each of these mazes.

14.8.4 Indicators

The indicators for this exercise are the distance traveled, the duration, the maximal speed (translation/angular), the minimal and mean forward looking distances

14.9 Left hip extension, number:8

14.9.1 Purpose

The purpose of this exercise is to monitor the left extension of the subject when he is supported by the walker.

14.9.2 Operating mode

The subject is put in a given location behind the walker and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

Before starting this exercise it is necessary to check if the subject position is correct. For that purpose a few extension will be performed:

- in the correct starting position before the extension the two yellow leds must be lighted
- the extension position is correct if the two yellow leds are off

The subject then has to perform hip extensions with its left leg. Between two extensions it is necessary to stop for at least one second. The LCD will display the total number of correct hip extensions that has been performed during the exercise. Preferably the subject shall restart from a position where the two yellow leds are lighted.

The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.9.3 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.9.4 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will increase when starting the extension, reach a maximum d_1 at time t_1 and stay there until time t_2 . Then it will decrease quickly to come back to the initial value at time t_3 . Hence the distance signal looks like a squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of an extension = $t_3 - t_0$
- up extension time = $t_1 - t_0$
- extension time = $t_2 - t_1$
- down extension time = $t_3 - t_2$
- extension amplitude = $d_1 - d_0$

14.9.5 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of extensions
- the mean, minimal and maximal values of the time duration of an extension
- the mean, minimal and maximal values of the extension amplitude
- the mean, minimal and maximal values of the up extension time
- the mean, minimal and maximal values of the down extension time
- the mean, minimal and maximal values of the extension time

Further analysis of the recorded data will require an external software (not yet designed).

14.10 Left hip flexion, number:9

The purpose of this exercise is to monitor the left flexion of the subject when he is supported by the walker.

14.10.1 Operating mode

The subject is put in a given location behind the walker and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

Before starting this exercise it is necessary to check if the subject position is correct. For that purpose a few flexion will be performed:

- in the correct starting position before the flexion the two yellow leds must be lighted
- the flexion position is correct if the two yellow leds are off

The subject then has to perform hip flexions with its left leg. Between two flexions it is necessary to stop for at least one second. Preferably the subject shall restart from a position where the two yellow leds are lighted. The LCD will display the total number of correct hip flexions that has been performed during the exercise. The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.10.2 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.10.3 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will decrease when starting the flexion, reach a maximum d_1 at time t_1 (the distance sensor does not see the leg anymore) and stay there until time t_2 . Then it will decrease quickly to come back to the initial value at time t_3 . Hence the distance signal looks like a positive squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of a flexion = $t_3 - t_0$
- up flexion time = $t_1 - t_0$
- flexion time = $t_2 - t_1$
- down flexion time = $t_3 - t_2$
- flexion amplitude = $d_1 - d_0$

14.10.4 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of flexions
- the mean, minimal and maximal values of the time duration of a flexion
- the mean, minimal and maximal values of the flexion amplitude
- the mean, minimal and maximal values of the up flexion time
- the mean, minimal and maximal values of the down flexion time
- the mean, minimal and maximal values of the flexion time

Further analysis of the recorded data will require an external software (not yet designed).

14.11 Right hip extension, number:10

14.11.1 Purpose

The purpose of this exercise is to monitor the right extension of the subject when he is supported by the walker.

14.11.2 Operating mode

The subject is put in a given location behind the walker and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

Before starting this exercise it is necessary to check if the subject position is correct. For that purpose a few extension will be performed:

- in the correct starting position before the extension the two yellow leds must be lighted

- the extension position is correct if the two yellow leds are off

The subject then has to perform hip extensions with its right leg. Between two extensions it is necessary to stop for at least one second. The LCD will display the total number of correct hip extensions that has been performed during the exercise. Preferably the subject shall restart from a position where the two yellow leds are lighted.

The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.11.3 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.11.4 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will increase when starting the extension, reach a maximum d_1 at time t_1 and stay there until time t_2 . Then it will decrease quickly to come back to the initial value at time t_3 . Hence the distance signal looks like a squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of an extension = $t_3 - t_0$
- up extension time = $t_1 - t_0$
- extension time = $t_2 - t_1$
- down extension time = $t_3 - t_2$
- extension amplitude = $d_1 - d_0$

14.11.5 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of extensions
- the mean, minimal and maximal values of the time duration of an extension
- the mean, minimal and maximal values of the extension amplitude
- the mean, minimal and maximal values of the up extension time
- the mean, minimal and maximal values of the down extension time
- the mean, minimal and maximal values of the extension time

Further analysis of the recorded data will require an external software (not yet designed).

14.12 Right hip flexion, number:11

The purpose of this exercise is to monitor the right flexion of the subject when he is supported by the walker.

14.12.1 Operating mode

The subject is put in a given location behind the walker and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

Before starting this exercise it is necessary to check if the subject position is correct. For that purpose a few flexion will be performed:

- in the correct starting position before the flexion the two yellow leds must be lighted
- the flexion position is correct if the two yellow leds are off

The subject then has to perform hip flexions with its right leg. Between two flexions it is necessary to stop for at least one second. Preferably the subject shall restart from a position where the two yellow leds are lighted. The LCD will display the total number of correct hip flexions that has been performed during the exercise. The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.12.2 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.12.3 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will decrease when starting the flexion, reach a maximum d_1 at time t_1 (the distance sensor does not see the leg anymore) and stay there until time t_2 . Then it will decrease quickly to come back to the initial value at time t_3 .

Hence the distance signal looks like a positive squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of a flexion = $t_3 - t_0$
- up flexion time = $t_1 - t_0$
- flexion time = $t_2 - t_1$
- down flexion time = $t_3 - t_2$
- flexion amplitude = $d_1 - d_0$

14.12.4 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of flexions
- the mean, minimal and maximal values of the time duration of a flexion
- the mean, minimal and maximal values of the flexion amplitude
- the mean, minimal and maximal values of the up flexion time
- the mean, minimal and maximal values of the down flexion time
- the mean, minimal and maximal values of the flexion time

Further analysis of the recorded data will require an external software (not yet designed).

14.13 Left hip abduction, number:12

14.13.1 Purpose

The purpose of this exercise is to monitor the left abduction of the subject when he is supported by the walker.

14.13.2 Operating mode

The subject is put in a given location behind the walker and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

Before starting this exercise it is necessary to check if the subject position is correct. For that purpose a few abduction will be performed:

- in the correct starting position before the abduction the two yellow leds must be lighted
- the abduction position is correct if the two yellow leds are off

The subject then has to perform hip abductions with its left leg. Between two abductions it is necessary to stop for at least one second. The LCD will display the total number of correct hip abductions that has been performed during the exercise. Preferably the subject shall restart from a position where the two yellow leds are lighted.

The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.13.3 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.13.4 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will increase when starting the abduction, reach a maximum d_1 at time t_1 and stay there until time t_2 . Then it will decrease quickly to come back to the initial value at time t_3 . Hence the distance signal looks like a squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of an abduction = $t_3 - t_0$
- up abduction time = $t_1 - t_0$
- abduction time = $t_2 - t_1$
- down abduction time = $t_3 - t_2$
- abduction amplitude = $d_1 - d_0$

14.13.5 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of abductions
- the mean, minimal and maximal values of the time duration of an abduction
- the mean, minimal and maximal values of the abduction amplitude
- the mean, minimal and maximal values of the up abduction time
- the mean, minimal and maximal values of the down abduction time
- the mean, minimal and maximal values of the abduction time

Further analysis of the recorded data will require an external software (not yet designed).

14.14 Right hip abduction, number:13

14.14.1 Purpose

The purpose of this exercise is to monitor the right abduction of the subject when he is supported by the walker.

14.14.2 Operating mode

The subject is put in a given location behind the walker and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position and the exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

Before starting this exercise it is necessary to check if the subject position is correct. For that purpose a few abduction will be performed:

- in the correct starting position before the abduction the two yellow leds must be lighted
- the abduction position is correct if the two yellow leds are off

The subject then has to perform hip abductions with its right leg. Between two abductions it is necessary to stop for at least one second. The LCD will display the total number of correct hip abductions that has been performed during the exercise. Preferably the subject shall restart from a position where the two yellow leds are lighted.

The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.14.3 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.14.4 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will increase when starting the abduction, reach a maximum d_1 at time t_1 and stay there until time t_2 . Then it will decrease quickly to come back to the initial value at time t_3 . Hence the distance signal looks like a squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of an abduction = $t_3 - t_0$
- up abduction time = $t_1 - t_0$
- abduction time = $t_2 - t_1$
- down abduction time = $t_3 - t_2$
- abduction amplitude = $d_1 - d_0$

14.14.5 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of abductions
- the mean, minimal and maximal values of the time duration of an abduction
- the mean, minimal and maximal values of the abduction amplitude
- the mean, minimal and maximal values of the up abduction time
- the mean, minimal and maximal values of the down abduction time
- the mean, minimal and maximal values of the abduction time

Further analysis of the recorded data will require an external software (not yet designed).

14.15 Plantar flexion, number:14

The purpose of this exercise is to monitor the plantar flexion of the subject when he is supported by the walker.

14.15.1 Operating mode

The subject is put in a given location behind the walker, a little bit farther than the correct position, and should have both hands on the handles. When starting the walker will put its brakes on. In this location he has to stand still in its final position. For this exercise it is necessary to adjust the position of the subject with respect to right rear distance sensor. The right position is obtained when the distance of the subject to the walker is such that the 2 yellow leds are lighted and get off when he is performing a plantar flexion.

The exercise starts if:

- the subject may present a rfid tag but it is not compulsory
- the caregiver hit the green remote key when the subject is ready.

The subject then has to perform plantar flexions (remember when the subject starts the plantar flexion the 2 yellow leds must be on and when he is up they must be off).

The LCD will display the total number of correct plantar flexions that has been performed during the exercise. The exercise is completed

- when the caregiver press the EXIT remote key
- or the time duration is larger than 20 minutes

On completion of the exercise the walker will release its brakes.

14.15.2 Cancelation and exit

It is possible to cancel the current exercise with the EXIT remote key.

14.15.3 Distance signal

When performing correctly this exercise the distance d_0 between the subject leg and the walker will stay constant, then at time t_0 will decrease when starting the plantar flexion, reach a minimum d_1 at time t_1 and stay there until time t_2 . Then it will increase quickly to come back to the initial value at time t_3 . Hence the distance signal looks like a negative squared wave signal. We will distinguish several parameters to characterize the exercise:

- time duration of a flexion = $t_3 - t_0$
- up flexion time = $t_1 - t_0$
- flexion time = $t_2 - t_1$
- down flexion time = $t_3 - t_2$
- flexion amplitude = $d_1 - d_0$

14.15.4 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the number of flexions
- the mean, minimal and maximal values of the time duration of a flexion
- the mean, minimal and maximal values of the flexion amplitude

- the mean, minimal and maximal values of the up flexion time
- the mean, minimal and maximal values of the down flexion time
- the mean, minimal and maximal values of the flexion time

Further analysis of the recorded data will require an external software (not yet designed).

14.16 Assisted walking, number:15

The purpose of this exercise is to help the subject to walk. As soon as the subject is far away from the walker the brakes will be set on in order to provide a fixed support that the subject may use for walking forward. As soon as the walker is close enough the brakes will be released so that the subject may move the walker forward.

The exercise is completed

- when the caregiver press the EXIT remote key

On completion of the exercise the walker will release its brakes.

14.16.1 Indicators

At the completion of the exercise the walker provides through rowe as exercise indicators:

- the duration of the exercise,
- the travelled distance,
- the maximal speed
- the maximal angular speed
- the name of the record file.
- the total duration of the no motion of the walker

15 Annexes

15.1 Fit-pc physical connection

Below the seat are provided:

- an extensible USB male connector with a USB hub
- an HDMI wire

The USB hub allows one to connect a mouse and a keyboard while the HDMI allows to connect a computer screen.

15.2 Troubleshooting

- *ANG-med is stuck in an exercise:* use the POWER remote key to switch off the computer. If this does not work press the OFF button of the computer, put the main switch in the OFF position and restart ANG-med

15.3 Short summary of pre-defined exercise

0. Dynamic walk (default exercise)
1. Correct position
2. Medical 10m walk
3. Time Up and Go (TUG)
4. ID creation
5. Position calibration
6. Handles calibration
7. Maze
8. Left hip extension
9. Left hip flexion
10. Right hip extension
11. Right hip flexion
12. Left hip abduction
13. Right hip abduction
14. Plantar flexion
15. Assisted walking

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