ARCHERY BALANCE TRAINER

USER MANUAL



Q: "What are the three most important things in your archery technique?"

A: "Balance, balance, and…. balance"

September 14, 2017

BALANCE TRAINER

1 Introduction

Standing is the human position in which the body is held in an upright position and supported only by the feet. This position looks static, but in reality is not.

The body is moving (body sway) forward and backwards. Archers use visual, proprioceptic (feeling) and vestibular feedback-loops to control this inherent unstable position[1]. And there are also external disturbances such as wind and wind gusts that add to this instability as well.

The archer's body needs to be as stable as possible.



The Wii Balanceboard can accurately[2][3][4] detect movements of the body center-of-gravity. This, in combination with the Archery Balance Trainer software provides the archer and coach with an efficient tool for training exercises tailored for archery balance training.

With the audio and rumble feedback provided by the system, archers can practice keeping and correcting their balance and also train their muscles and central nervous system to quickly and efficiently detect and react to external disturbances like wind and wind gusts.

Also, archers can check the consistency of their shooting form, by comparing the center-of-gravity movements from one shot to the other.

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[1] *"Postural Stability during Static Upright Stance in Archers"*, Katerina Stambolievaa, et.al., Posture, Balance and the Brain, International Workshop Proceedings, ISBN 978-954-92521-7-0

[2] *"Validity of the Nintendo Wii® balance board for the assessment of standing balance in Parkinson's disease"*, Holmes, J.D. et.al., Clin. Rehabil. 2013 27: 361 originally published online 7 September 2012

[3] *"Accuracy of force and center of pressure measures of the Wii Balance Board"*, Harrison L. Bartlett, et al., Gait & Posture 39 (2014)

[4] *"Balance exercise for persons with multiple sclerosis using Wii games: a randomised, controlled multi-centre study."*, Nilsagård, Y.E., et.al., Mult. Scler. 2013 19: 209 originally published online 6 June 2012

2 Installation

The Balance Trainer comes in three different forms;

1. As a complete ready-to-run hardware box called the **Balance Trainer System**.
2. As a do-it-yourself micro SD Card image for a Raspberry Pi 2B.
3. As a do-it-yourself compiled software package for a Linux distribution.

To use the Balance Trainer (in any of the above forms), you also need:

- An original Nintendo Wii Balanceboard
- A Nintendo Wiimote or equivalent
- A Computer screen with HDMI input and HDMI cable
- A standard 5V 2A micro USB power supply[5]

2.1 Balance Trainer System



What's in the box? The Archery Balance Trainer System consists of a Raspberry Pi 2B in a small black housing. In one of the 4 USB ports, a Bluetooth dongle is installed. The micro SD Card reader of the Raspberry contains a micro SD Card with the operating system and the Balance Trainer software. A pin code is written on the back of the system. This pin code is only valid for this specific system.

Installation of the Balance Trainer system is straightforward;

1. Connect the computer screen via the HDMI cable to the Balance Trainer box
2. Connect a USB mouse (wired, or through a dongle)
3. Connect the 5V 2A micro USB power plug (the system will boot up immediately)
4. Go to Setup

2.2 Raspberry SD Card Image

1. Download the micro SD card image from the website (the image is 16Gb so make sure you have at least this amount of free disk space).
2. Download and install Win32 Disk Imager from this link: http://sourceforge.net/projects/win32diskimager/files/latest/download
3. Unzip it.

[5] 2A is recommended for the Raspbarry Pi 2B to operate stable. Less than 1A will not do.

4. Plug the SD card into an SD card slot or adaptor for your PC.
5. Run the unzipped Win32DiskImager.exe application (may just be shown as Win32DiskImager depending on your windows settings)
    a. Ensure the correct driver letter is selected for the SD card – double check this is right in Windows Explorer as Win32DiskImager will overwrite the entire drive without warning if the wrong drive is selected!
    b. Select the unzipped image file
    c. Press Write and wait for the program to write the operating system onto the SD card.
6. Once the writing is done plug the SD card into the Raspberry Pi 2B and power it up
7. Go to Setup

2.3 Linux Software Package

The Linux software package is the most complex solution. It requires a laptop with Linux and a Bluetooth adapter (internal or external USB Bluetooth dongle). The Balance Trainer software can be downloaded from the website as a tgz file. Note that this software needs to run on Linux, and has been tested on (L)Ubuntu 14.10 and older versions but should run on other Linux flavors as well. Most Linux Desktop installations have everything you need, except for Tcl/Tk and Bluetooth packages. Installation depends on your choice of Linux. On (L)Ubuntu, this should work

```
sudo apt-get install tk8.6
sudo apt-get install tcl8.6
sudo apt-get install bwidget
sudo apt-get install bluetooth
```

Download the correct software package from the website, and unpack it

```
tar xvfz <file>
```

Start with

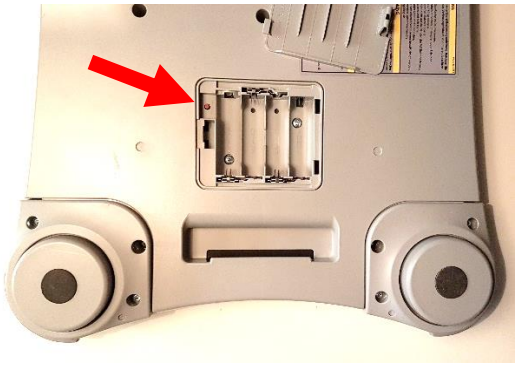
```
./start.sh
```

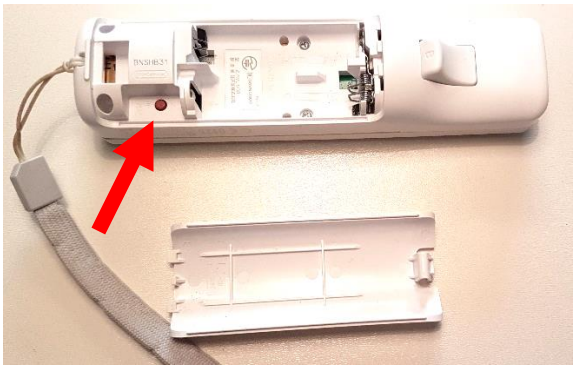
Go to Setup

3 Setup

If the system is booted up, it starts the software automatically. When the Balance Trainer software runs, you need to connect the WiiMote and the Wii Balanceboard to the software.

Make sure the Balance trainer system is up and running. Now open up de battery cover on both the Wii Balanceboard and the WiiMote and find the small red 'pairing' buttons.





3.1 License Key

If you have purchased the complete Balance Trainer System, the license pin is already activated and you can skip this section.

If you downloaded the SD card image or the Linux software, the first time you try to setup a connection with (menu Connection → Connect) a license dialog is shown. If you've already purchased an unlock pin, enter it here and unlock the software. If you've downloaded the SD Card image or the Linux software and want to test your setup, use as pin 1234. This will enable you to pair the two devices with your system. If successful, you have 30 seconds to make sure the signals of both devices are received (just move the WiiMote and slightly press one of the Wii Balanceboard's feet).

An unlimited Pin can be purchased from the developer upon request.

Request a pin code here: abt@vapeldoorn.net

If you have made a mistake in entering the pin you can reset the license in the Help menu.

3.2 Connecting/Pairing



With the software running, and the two small red buttons of both Wii's exposed (battery covers open). Select the menu Connection → Connect. A dialog pops up explaining what to do. Press the Ok button, then ***first*** press the red pairing button on the Wii Balanceboard and ***wait 5 seconds*** and then the red pairing button on the WiiMote. After some time, the system should respond with "found 2 WiiMotes".

If no Wii's are found, repeat this process.

If both Wii's are found, but the Wii Balanceboard looks unresponsive, repeat the process and make sure you pair the Wii Balanceboard first, then wait 5 seconds before pairing the WiiMote.

If both Wii's are found and responsive, you are all setup.

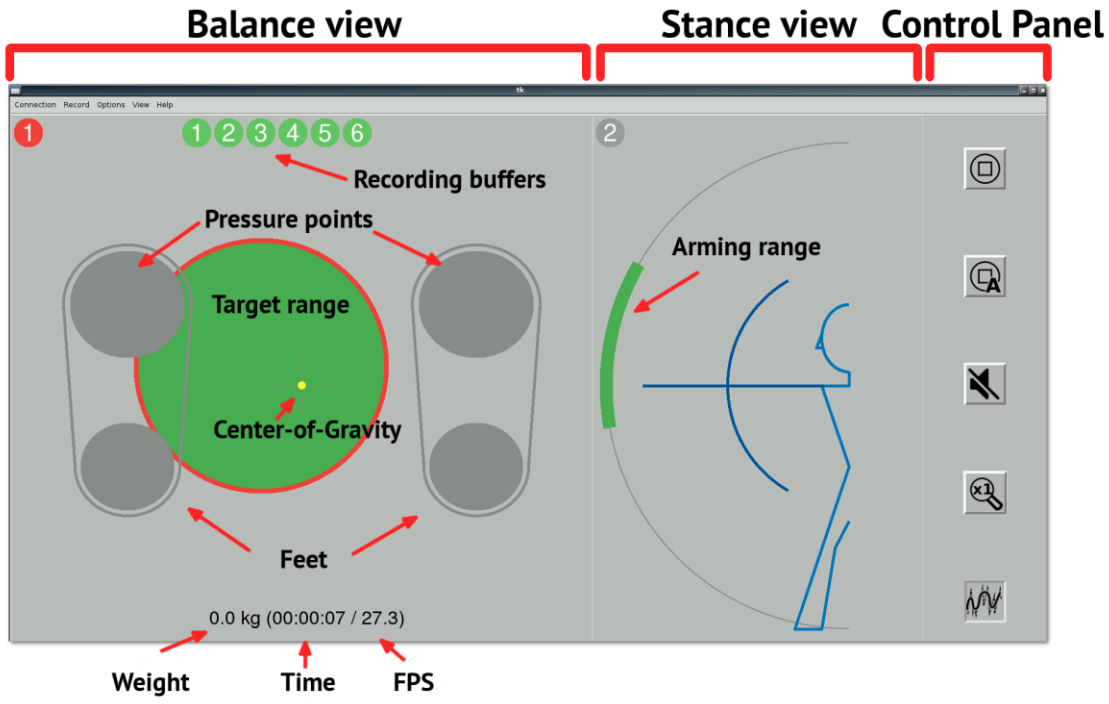
Note: Due to the Nintendo secret (nonstandard) Bluetooth protocol, it is impossible to keep the pairing in between sessions. Each new session (each restart of the software) this pairing needs to be done. Also be aware that the Bluetooth range is limited. If the archer walks to the target with a paired WiiMote on the arm, the pairing is lost and needs to be done again. Therefore it is best to take-off the WiiMote and leave it at the Wii Balanceboard before walking to the target.

4 Using the Balance Trainer

The Balance Trainer works by measuring the center-of-gravity of the archer standing on the Wii Balanceboard and comparing this with a target area. If the system is ***armed*** and the center-of-gravity moves ***outside*** the target area an alert signal is given. This alert signal can be an audio signal, or a rumble (the WiiMote attached to the archer's arm starts to vibrate) or both.

4.1 The Interface

The interface of the Balance Trainer program is divided into two main frames. On the left is the balance frame. On the right is the stance frame. The balance frame shows the real-time measured center-of-gravity of the archer. The stance frame shows the real-time measured position of the bow-arm. On the far right is a control panel and on the top is a menu bar and at the bottom a status bar.



4.1.1 The Balance View

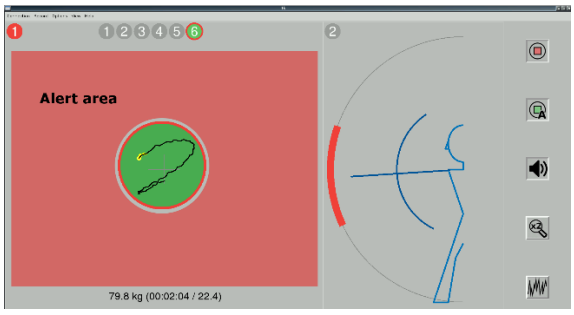
The balance view consists of two feet outlines, representing the archer's feet, with each foot outline containing two pressure circles (so 4 pressure circles in total). In the center of the view a small yellow dot represents the archer's measured center of gravity. When the archer moves his body, the center-of-gravity dot moves (and leaves behind a history trail) and the pressure circles indicate the weight distribution of the archer in different colors.

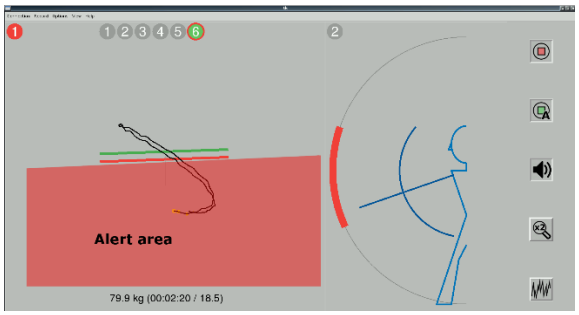
At the bottom, the weight of the archer is displayed, the time the system is up and running, and the average frames-per-second that the system refreshes.

A big green circle is shown. This circle is called the ***target area***. The target area is green, with a red outline. If the center-of-gravity lies within the green circle, the system is quiet. No audio signal and no rumble is felt. When the center-of-gravity moves out of the target area and into the alert area, an alert is given.

Two types of target areas can be selected (in the menu Options → Range);

- A green circular area with a red outline; The circular target range sounds the alarm when the center-of-gravity moves outside the circle. You can move the green area with the mouse by left-click and hold, then move the area. You can change the size of the area by keeping the pointer inside the area and turning the mouse wheel.
- Or two (green and red) parallel lines; The target range with two straight lines, sounds an alarm when the center-of-gravity crosses the lines to the side of the red line. You can move the two parallel lines with the mouse, by left click and hold on either of the lines and move. You can rotate the lines by hovering the pointer over the lines and turning the mouse wheel.





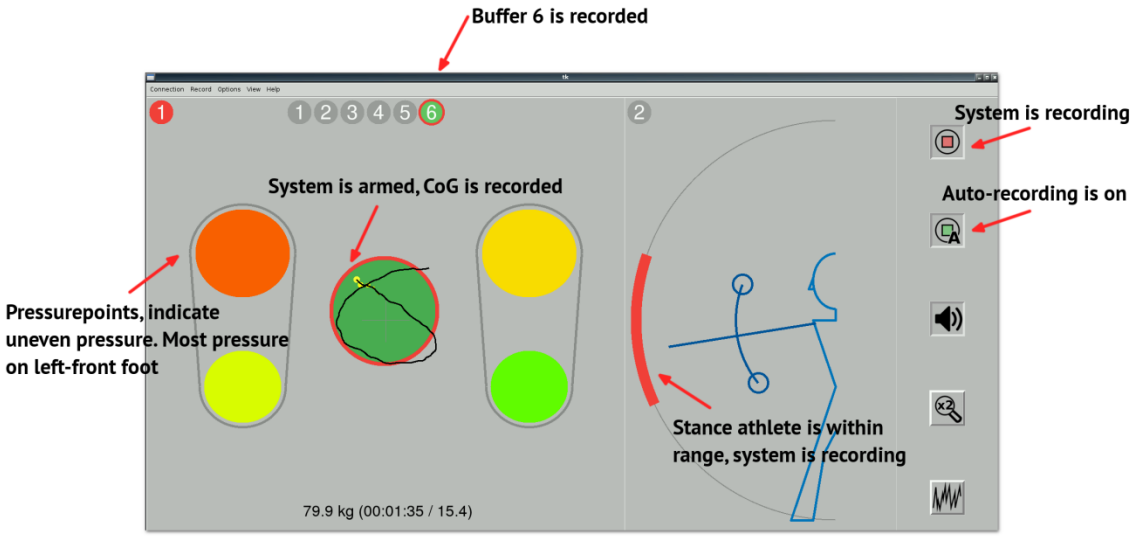
The purpose of the balance trainer lies in the fact that the archer learns (through audio and rumble feedback) to recognize (upper) body movements that result in shifts in the center-of-gravity and how to correct this. Therefore, there is a 'target' area for the center-of-gravity to be in. Once outside this 'target' area (and armed), the system starts the audio signal and/or the rumble effect on the WiiMote.

To ***arm*** the system, press the record button 

Manually arming (and disarming) the system can be done by a coach. Once the archer is almost or at full draw, the system can be armed and the movement of the center-of-gravity is recorded and an alert is given if it moves outside the target area. After the arrow is shot, lots of movement happen and the system will for sure give an alert. To prevent this, the coach needs to disarm the system by clicking the record button again.

Instead of having the coach arm and disarm the system, automatically arming and disarming can be done using the WiiMote, based on whether the archer is at full draw. This is explained in the next section.

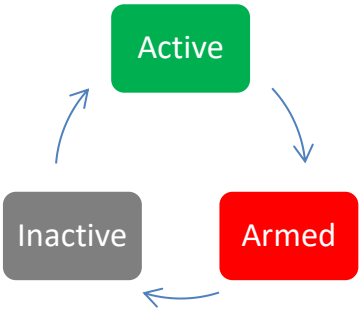
4.1.2 The Stance View



The stance view shows the archer's side view. The arm position is measured by the WiiMote (which is attached to the arm) and shown in the stance view.

The Stance view is used to automatically arm and disarm the balance trainer. In auto-mode, when the system is ***active*** (the stance bar is green) and the bow-arm is lifted and points ***inside*** the green bar. The green bar turns ***red*** and the system is ***armed***. In this armed state, whenever the center-of-gravity position is outside the green balance area, the system will give an alert.

When the archer shoots and drops the bow-arm, the system goes into ***inactive*** mode for a short period of time, before entering ***active*** mode again.

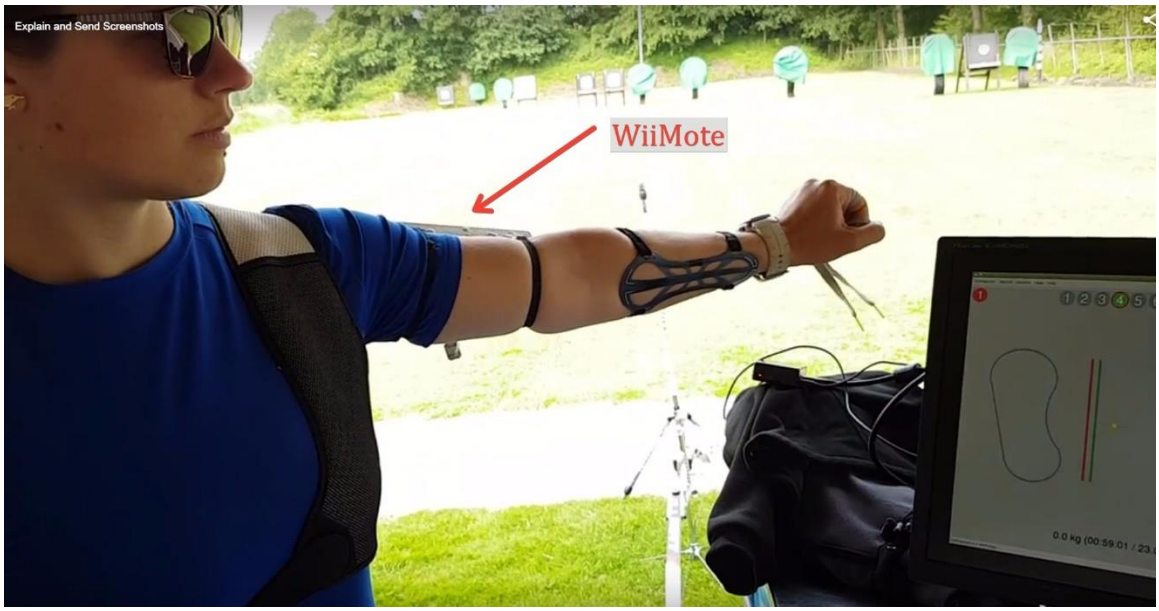


4.1.3 Attaching the WiiMote

If you have a spare armguard (e.g. a Beiter-like armguard works well). Attach the WiiMote with double sided adhesive tape to an extra armguard as shown in the next picture.

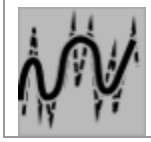
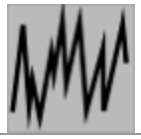


Now put this extra armguard on, such that the WiiMote is on the outside of the upper arm of the bow-arm and is pointing towards the target when the bow-arm is at full draw. Make sure that the buttons of the WiiMote are facing up. As shown in the next picture of an archer wearing the WiiMote.



4.1.4 The Control Panel

The control panel consists of buttons that turn functions on or off.

Button		Function
		Press to ***arm*** or ***disarm*** the system. When armed it records the center-of-gravity path (and alerts through audio and/or rumble). Doesn't matter where the bow-arm is. You can operate the system without a WiiMote on the bow-arm (only connect a Wii Balanceboard)
		Use the bow-arm position to automatically arm and disarm. You need to connect both Wii Balanceboard and the WiiMote to use auto-recording.
		Indicates whether the audible signal (when the center-of-gravity is outside the target area) is muted or not.
		The signal is multiplied 1x, 2x, 3x, 4x or 5x times. The higher the number the more accurate the system becomes
		Indicates whether the signal from the Wii Balanceboard and WiiMote is smoothed or raw.

4.1.5 The Menu

Besides the control panel buttons, the system can be operated through a menu. It's items are explained below;

Connection		
	Connect	Set up a Bluetooth connection to the Wii Balanceboard and the WiiMote
	Simulation	Simulate a connection to a Wii Balanceboard and a WiiMote. This way you can 'learn' the interface and try stuff without actually connecting the Wii's
	Quit	Quit the software
Record		
	Auto Record	 Turn on auto arming
	Record	 Arm the system
	Calibrate	To reposition the drawing of the center (and the feet).
	Select	Select buffer 1 … 6 to use for recording
	Show	Show the recorded path of buffer 1 … 6
Options		
	Sound	 Turn on/of sound
	Rumble	Turn on/off the rumble/vibration of the WiiMote
	Accuracy	The center-of-gravity path is multiplied 1x ... 5x. 1x is least accurate, 5x is max accuracy
	Range	The target area can be either a circle or a line
	Re-arm delay	Set the re-arm time delay from 0 sec … 20 sec.

	Alarm sound	Choose an alarm sound
	Signal smoothing	Smooths the signal from the Wii Balanceboard
	Bezier lines	Draws smooth lines on the display (when recording). This introduces a small performance penalty (so for highest performance, highest frame-rate, turn this off)
	Performance mode	Performance mode on/off. When on, the lines are drawn in a higher performance mode, resulting in an improved frames-per-second.
View		
	Show grid	Turn on/off the grid
	Show feet	Turn on/off the feet outlines
	Show axis	Turn on/off the axis
	Show pressure	Turn on/off the pressure indicators in the feet (this improves frames per second performance slightly)
	Sport	Choose a sport (only changes the archers symbol) from Recurve Bow, Compound Bow, Pistol, Rifle
	Theme	Choose different color themes (requires a restart of the software)
Help		
	Help	Show the manual
	Reset License	Reset the license file (you need to enter the pin code again)
	Reset Options	Reset the options to default (requires a restart of the software)
	Info	Shows the info dialog
	Copyright	Shows a copyright and disclaimer statement

4.1.6 The Status Bar

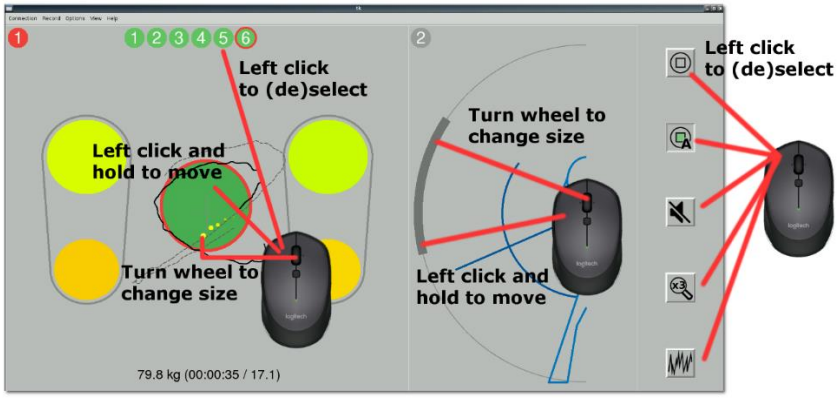
The status bar indicates some feedback on menu items, indicates which Wii's are connected and the version of the software that is currently running.

4.2 Controlling the Balance Trainer

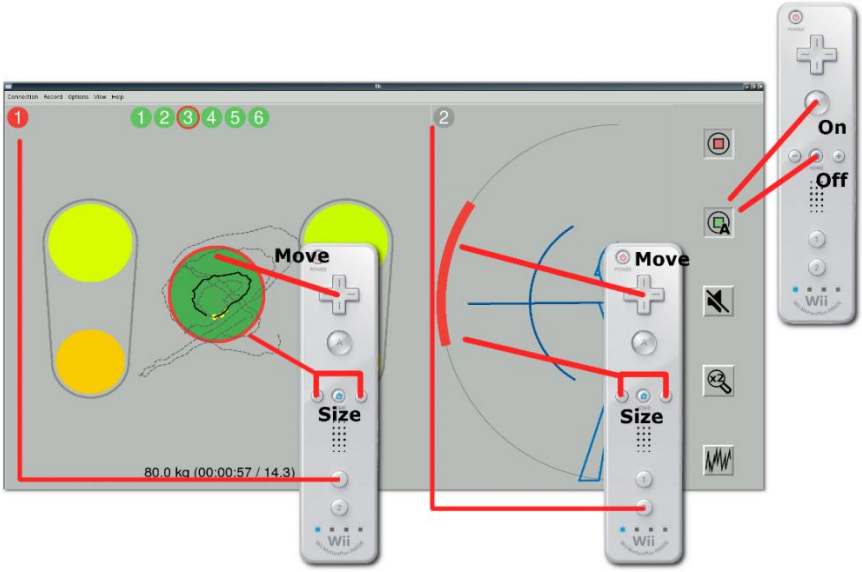


Typical control is done using a mouse that is connected to the system. One of the three free USB ports can be used to attach a wired USB mouse, or a USB mouse dongle.

The main use of the mouse is to click on the buttons in the control panel, operate the menu and move and change the size of the target area in the balance frame or the reference area in the stance frame. See the next picture.

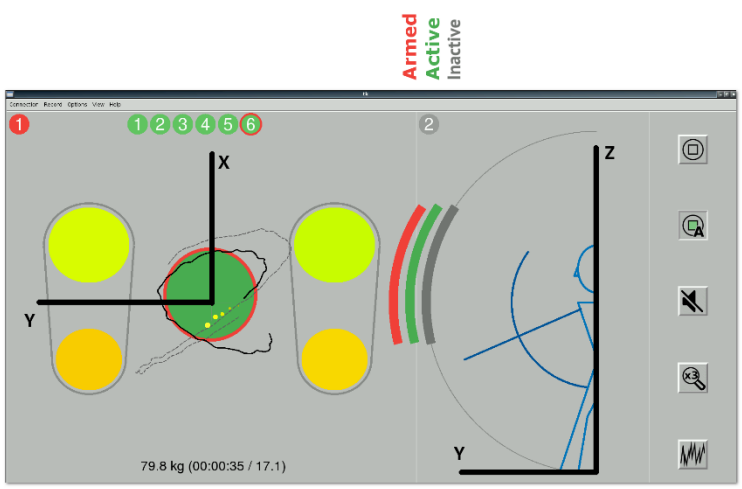


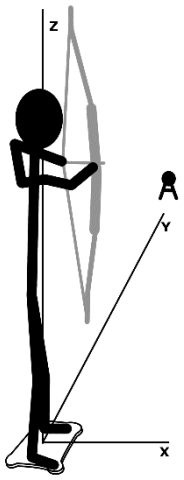
An alternative way of controlling the software is through the WiiMote itself, as shown in the next picture. When using the WiiMote, first use button 1 or 2 to select the Balance frame (1) or the Stance frame (2). Then use the move and size buttons to move and change the size of either the center-of-gravity target area or the bow-arm target area.



4.3 Coordinate Systems

The Wii Balanceboard needs to be placed on the shooting line as shown in the figure below (for right handed archer).





5 About the Operating System

The operating system is called Raspbarian (which is a Linux derivative). If for some reason you have exited the Balance Trainer program, you see an empty screen with the Balance Trainer logo on it. On this screen, right click to get a menu.

Desktop Menu Item	Function
Balance Trainer	Start the balance trainer program
Balance Trainer (no aplay)	Start an alternative variant of the Balance Trainer (if you have problems with delayed audio, this might help)
Reset Balance Trainer Options	Resets the Balance Trainer options to default
Manual	Shows the PDF User Manual
Maintenance	No need to use this! Use at own risk!
Shutdown	Shutdown the system

Tip; If a window disappears behind the Balance Trainer window, use Alt-Tab to get it in front again.

6 About the Author



The Balance Trainer system is developed by Marcel van Apeldoorn, an archer since 1991, also a former international archer and currently national compound coach of the Archery team of the Netherlands. He represented the Netherlands at World Championships, European Championships and other international events as (recurve) competitor and (recurve and compound) coach for more than 25 times. In his professional life he has a Master of Science degree in Aerospace Engineering, and holds a position as Senior Research and Development Engineer in the domains of Air-Traffic-Control systems, Software Analysis and Design, Software development, Human factors and Training at the NLR – Netherlands Aerospace Centre in Amsterdam.

To contact, use abt@vapeldoorn.net

"The idea for the balance trainer dates back to 2009 when the Wii Balanceboard came on the market. As a software professional I knew the (secret) Bluetooth protocol that Nintendo uses would be reversed engineered and it was just a matter of time before enough information was found on the internet about this. This enabled me to build a system that was able to measure the center-of-gravity movements of an archer.

One of the nice features of the Wii Balanceboard is that it is actually pretty accurate and a very inexpensive alternative to laboratory-grade force plates[6] with very accurate repeatability within a single board. This makes it more than just a toy, but a very useful tool in the training of archers."

Marcel van Apeldoorn

September, 2017

[6] See for example *"Accuracy of force and center of pressure measures of the Wii Balance Board"*, Harrison L. Bartlett, et al., Gait & Posture 39 (2014).
[From conclusion] *"In conclusion, the WBB is an inexpensive, portable device that may be useful for measuring vertical ground-reaction forces and COP with limitations on accuracy and precision."*

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