Interactive motion tracing for Rowing Training

Dai, Zheng

Published in:
Proceedings of the 11th Danish Human-Computer Interaction Research Symposium

Publication date:
2011

Document version
Accepted manuscript

Citation for pulished version (APA):
Dai, Z. (2011). Interactive motion tracing for Rowing Training. In *Proceedings of the 11th Danish Human-Computer Interaction Research Symposium* (pp. 79-82). Copenhagen Business School, Dept. of IT Management Communications.
https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxkaHJzMjAxMXxneDoxMDQyY2Q4N2QzZDNjZjRm&pli=1

Interactive motion tracing for Rowing Training

Zheng Dai
Mads Clausen Institute
University of Southern Denmark
Alsion 2 ,CPD,6400 Sønderborg
+45 6072 8081
twindai@gmail.com

Abstract

This paper studies motion tracking and team coordination for the training of rowers. The design research is drawn upon the division of contribution between the designers input and the user input in a design process. We built a training system that can record and show the action of a rower's hand. Designer proposed solutions for both a fundamental problem and a very advanced problem. Users guided the design direction, and spoke what they expected or what they disliked. As the result, our design provided a real-time recording tool for rowers and coaches to discuss and analyze the motion. The coach can correct the path immediately and save the corrected path for the rower to try to imitate and train. The members in a rowing team train with the same path from to coordinate and synchronize their actions for the best performance. The training system was developed through a user-centered design process with Danske Studenters Roklub. It was designed in iterations to provide a new experience for rowing sport training by coaching in real-time, training interactively, and perceiving directly.

Keywords

Motion tracing, rowing training, team coordinate.

1. introduction

The right action and gesture take an important part in rowing training. A coach needs to demonstrate and correct rowing techniques in person. Currently, there are several systems that help for rowing training. These systems adopted different methods and processes including motion capture, virtual trainer, real sense feedback, and video analysis. [6,8,11]. There are also some researches focused on indoor rowing training [1,12]. But less system provides a friendly environment for the interaction between coach and rower. This paper describes a project that aims for providing a real-time indoor coaching system for a rowing team. This project is working with Danske Studenters Roklub (DSR) for improving their training experience. During our research and communication with DSR, we found that training is a communication between the coach and the rower, and we decided to focus on the movement of hand and paddle. We believe that the training system should provide useful information for both coach and rower to analyze and learn. To reduce the misunderstanding and to build better communication, the information should be more direct and clearer, and people can interact with it to help them communicate. Self-learning and team coordination are also in our consideration in this system, and that is very necessary for lowering the cost of coaching.

2. The Research

The target user of our research is DSR. They have both outdoor training and indoor training facilities. As user input, the coach shows us his process and techniques of coaching. The main approach is video analysis. When they train outdoors, the coach drives a motorboat and uses a video camera to record the rowing boat. After they get back to the training HQ, the coach analyzes and explains action by action the earlier training on a screen. There are two main issues that perplex the coach. At first, the correction is not in a real-time. There is much time difference between video recording and correction. For dealing with this issue, the rowing team adopts a world famous indoor rowing simulation machine, concept2. [4] The coach can see and correct rower's action indoor and in real-time. But rower can only follow the right action when the coach is beside him. When they train individually or rowing outdoors, they will have a hard time remembering the right action. The second issue is that the video recording can't show the motions directly and accurately. The coach tries some motion tracing technologies that are installed on the boat with wires. But the rowers feel that the device adds additional burden on the boat and changes the feel and sensation of rowing. The collected data will be analyzed after outdoor training, and software will redraw the motion of the rower. The path is accurate, but it is not for real-time coaching, neither. These dilemma and obstacle are the initial users' input.

We have more research on indoor training with the rowing machine Concept 2. Concept2 has an ergometer with monitor. It can show a graphic of the velocity, the distance, and the force. The coach rows first, and the monitor lists the history of the motion as graphics. The rower needs to remember which history the coach records, and then the rower is needs to perform an action that gives a similar graphical pattern as the coach's pattern. Actually it is a behavior of imitating and matching. But the machine doesn't provide a user friendly way. This investigation inspires us to design a similar way to show information to the user. Based on the investigation and previous experience, the design concept is a part of designer's input. We also investigate virtual reality. Actually, Alessandro et.al built a training system with VR, and their focus is on machinists and the view from a rower's eye. [12] Lindholm Høje Museum in Aalborg exhibits an interactive rowing game with VR to demonstrate how ancient Vikings rowed there the ships. We take these suggestions back to our users. We all think it is a nice way to get a fantastic rowing experience for indoor training, but it would not help to demonstrate the right motion and rhythm, the coach still needs to analyze video clips.

During a discussion with DSR, we list out the new ideas and the old training methods to find a balance and connection. Because the old training methods are reliable and the fact that we are not just developing a game for fun we need to find a way to incorporate users input that is critical to evaluate to what extend the new ideas can be accepted for a practical training. The designer's input is investigation, results, new concepts, and analysis diagram. We find out that the rowing team needs a new idea of real-time correction and direct motion capture, meanwhile, they want to keep the traditional way of training with the Concept 2. To combine these 2 points, we designed a system that can recode the motion path and show it on the wall in front of the rower. The coach could point on the visible path and explain the right or wrong of an action. It provides a direct approach for analyzing, communicating, imitating, and training. We show our prototype to the rowing team. The coach and the rowers give us feedback. They could try to use any technology to record the motion, but none of them could help them to correct the motion. As the goal of training is to perform a right action, our users need a way to correct the wrong action. We can also see the same need from daily sport training. [10] Therefore, we decide to integrate a correction function into the next version. In the later iteration, more and more functions are added in to the system. People have suggestions and needs from varied perspectives. Lead user and common user have different ways to use our system and get different information. Finally in our system, it includes three steps for rowing training: The recording, the correction, and the matching. Each function represents a level of cognition.

3. Motion Path Recording

Human friendly design needs understandable information. As above-mentioned, we are going to recode the motion path and to show it on a screen or on a wall. Therefore we study the rowing process and got a research question: "What is an easier and more understandable way to show the motion path?" During our research, the coach is always trying his best to explain by simple and clear way. He catches the key points and emphasis, and tries to use easy and direct way to teach rowers. He proposes requirement and expectation to our training tools. On the one hand, the coach hopes our sports training tools can capture a motion as real as possible; on the other hand, he needs to make the rower understand the right motion easily. The coach told us he mainly focuses on some key position of a rower's hand. These positions can be connected one by one, and form a motion path. He draws this path on whiteboard or paper to explain the right position and motion. Following this traditional way of communication, we use accelerometer sensors to instead of the coach's eye, and use screen and projector to instead of whiteboard and paper. The position sensor provides a more accurate and original motion data. The screen and projector draw and refresh motion path in real-time. The important is that a computer will generate an understandable path by filter out complicated and useless raw data and provides a recordable history. Moreover, when the rower reviews the recorded motion paths and studies deeper his/her actual action, the simplicity of these paths information becomes more vital to the rower. Try to imagine, dozens to hundreds paths include thickly dotted potions. That is nearly impossible to process and analyze. As Figure 3-1 shows, the path looks smooth, but it is hard to catch the key point. The learner cannot performance another path exactly like this. In addition, this information cannot show time and speed different by an obvious way.

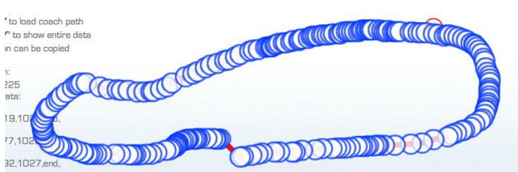

Figure 3-1 complicated path information

4. Build the System

The system that we build includes a mechanical paddle, motion capture sensor and hardware, and a laptop that is connected to both the hardware and a projector. The system shows as Figure Figure 4-1.

Figure 4-1Systems settings

The sensor capture is based on an electronics prototyping platform called Arduino. [7] We use an accelerometer to capture the motion of one end of the paddle in 2 directions. It represents the movement of up and down, or front and back. These 2 directions are represented by X and Y-axis on the computer screen and projected on the wall. The signal is generated by accelerometer and captured by an A/D convertor on Arduino, and sent to computer by a USB connection. This USB connection is treated as a COM port in the in PC. Following the guide on Arduino Playground, [7] we deployed a serial port convertor programs called SerialServer to transfer data from COM port to TCP/IP port. In my system, we used Adobe Flash as a user interaction program. Flash can get data from TCP/IP port, process the data, and use the data for animation and user interaction. When the capture starts, Ardurino will give a signal that the frequency is 25 per seconds. It is just enough for making an animation for human eyes. In the Flash programming, the system also set a threshold to filter the captured data when every two points have a distance of 40 pixels. In this way, the captured point becomes clear and understandable, by showing the difference of both time and position. User can change the threshold. We provide a handle for adjusting the capturing distance. (Figure 4-2).

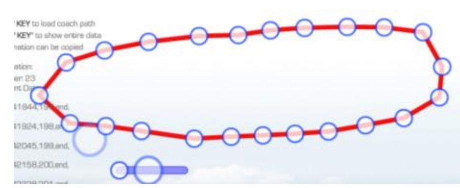

Figure 4-2 **Capture distance changing handle**

This handle design was part of designer's reflection-in-action. It is an obvious need of our designer. The same as Schön mentioned, "The project would talk back to practitioner what the conflict and problems are and where he has opportunity to solve the problems"[9] (p239). An efficient and effective reflection-in-action should be based on the interview and study with user. Basically, it is dangerous to pretend that a designer himself as the user to decide all the design solution. Thus get rich knowledge from user, and keep interaction with user during design process is the way to keep the design in the safe range. The rich information from user relies on the interviews and every discussion. In another words, designer’s input rely on user’s input. Designer translates user’s idea, and combines his own recognition to make detailed design decision, and directly forms the product. After that, a cycle starts, user gives feedback and gets inspiration to generate the next user input, then the designer gets inspiration from user input, and combines them with his reflection-in-action to generate next designer input again.(Figure 4-3) From this iterative process, designer gets closer to user, and understands user’s way of ideation better and better. The reflection of the designer will be more accurate to match user’s need.

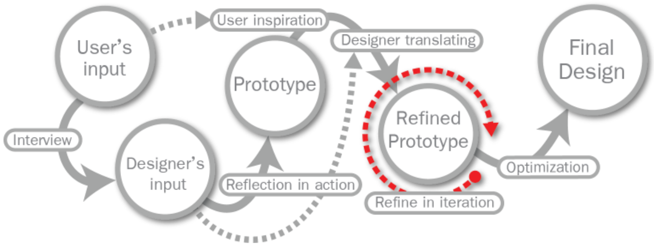

Figure 4-3 **design input and user input to design result**

User has a vague vision about what they need, [13] but can't speak out the exactly form of the design. Designers help users form their idea, and the very important is that designer sees the essential and core of the user’s need, but not just one idea on the surface. Moreover, designer knows what resource they can use to reach a practical way that can realize user’s expectation. The result of this interpretive work may have bias from user’s original purpose. As I mentioned above, it will be closer to user’s vision along with more iterations done, but the bias still exists. At this point, User’s feedback is not only the inspiration for new ideas and new function, but also includes what the wrong or unnecessary design they saw from the bias. The feedback reduces and eliminates the bias step by step. Thus the designer can predict more accurately during later reflection-in-action. The coach has responsibilities to train several rowers. But it cost lots of energy and time for correcting everyone’s motion and path. We purpose a solution to use computer to recode the coach path. Firstly, the coach performs several good motions, then he chooses the best one and save it in the system. Later on, he can load it as training standard or as a reference. The rower will study the coach path, and practice by matching it without the supervision of the coach. This approach allows the coach prepare an elaborative motion with deeper thoughts and put it into a visible format. Another coaching function is correction. The coach tells us, it is often to see that a rower has a customary motion. It may include a mistake or a core problem at a certain key-point. Thus the coach would like to correct this key-point with keeping other point. This way can make rower easier understand where the motion problem is, and how to correct it. (Figure 4-4) For performing this correction, the coach can use either the paddle or the mouse to drag the key-point. He can also move the cursor to an expected position first, and then push a key to automatically find out the nearest key-point. (Figure 4-4)

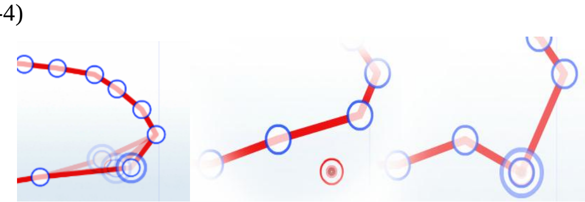

Figure 4-4 **correction functions**

Based on the individual training, and going along with the iteration of getting deeper and deeper, the coach hopes the system can also fit for team coordination training. As we know the rowing sport may need up to 8 or more people to row on one boat. The same rhythm and motion path are critical to the success of the coordination. As I mentioned above, the coach can save a perfect and adjusted motion path to support rower training. The same coach path is studied and matched by all members in a rowing team. No needs to gather the all members, everyone can train separately by referring to the same path. The system will show the rower’s path and the coach path at the same time. (Figure 4-5)

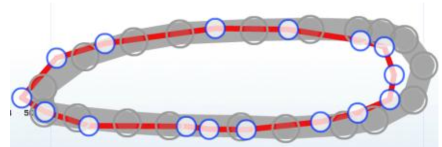

Figure 4-5 comparing rower path and coach path

5. Test procedure

After several iterations and communication with DSR, we take the whole system to them for an observation of using a relatively completed system. It is different from previous test and iteration. It is not for developing more functions, but for testing the feasibility. We gather a rower, the coach, the interaction designer, and the mechanical designer together to observe the usability. Following the process we designed, the coach makes a standard coach path, and the rower tries to match it. However we find that the rower feels hard to match both rhythm and path at the same time, and the number of key-point is also different between each path. Moreover, the coach finds out, because the size of rowers is different, the rower path may have different scale. The most important is not matching the position of a coach path, but is the rhythm and the shape of a coach path. Therefore, we decide to collect some objective data from a traditional way of coaching. The coach is correcting the rower without use our system, meanwhile, the system records rower’s motion path and rhythm. Until the rower gets a satisfied motion, we stop recording. We also record several coach paths that the coach feels satisfy. Later on, we analyze the basic feature of these rowing data, such as cycle time, the number of key-point, and the proportion of width to height for each path. We analyze three groups of data: the rower’s original rowing path data, the corrected rower’s path data, and the coach path data. The table Figure 5-1 indicates that the coach path has average about 18 key-points in each path, the proposition of the shape is approximately 5, and the cycle time is about 1.5 seconds. Comparing with the coach path, the rower’s original data has about 15 key points, the proposition is 3.8, and the cycle time is about 1 second. All these three aspects are higher than rower’s. After manually correction by the coach (without using our system), the corrected rower’s path is higher than the original. The corrected path has 16 key-points, the proposition is 4.25, and cycle time is 1.4 second. That means the shape of the path should be wider, and the rower should be more careful about the detail of a movement rather than a fast cycle. This point is also proofed by a following test with a common user, and based on it, when the rower uses our system to study a coach’s path, he will put focus on wider shape, more key-points, and average about 1.5 second a cycle.

		Rower Orignginal Path						Coach Corrected Rower’s Path						Coach Path				
		x/w	y/h	No.	Time	W/H		x/w	y/h	No.	Time	W/H		x/w	y/h	No.	Time	W/H
Path 10	max	1040	491.7	13	3.58	1055	max	988.8	512.35	17	3.93	1437	max	1168.3	492.8	21	4.15	1721
	min	443.8	325.25				min	262.2	327.45				min	296.95	282.85			
	dist	596.15	166.45				dist	726.7	184.9				dist	871.35	209.95			
				15	3.81	1073				16.1	4.25	1431				18.2	5.1	1528.3
Average				15	3.81	1073				16.1	4.25	1431				18.2	5.1	1528

Figure 5-1 **three groups of rowing data**

We take the same rowing system to Sønderborg local rowing club (SRC) without any modification to see the feedback from common user. The SRC is lower level than DSR as they are not aiming for the Olympic games. But they are far more professional than an individual amateur user. As I mentioned above, the DSR is the lead user in the rowing field, and they represent the highest need of rowers. Because the system was developed with DSR step by step, it should fit most needs of the common user. The test with SRC is held in a rowing training exhibition (Figure 5-2). Some friends and rowing amateurs also come. The members of SRC have similar comments as the DSR. They care more about the cycle time and the shape of a path, and they don't need to match accurate positions of the coach's path, (actually our system didn't have an evaluation function for matching). They also said that the training system is very good to them to use in a direct visible way to compare between any different rowing paths. Some of the amateur likes the matching idea very much. They like studying by following the coach's path completely. They trust this is a faster and necessary way for training a right motion from the very beginning. From these comments we can see that our system provide information from different aspects, a user has his own way to use the system and get focus on different aspects of the information.

Figure 5-2 **rowing training exhibition**

6. Conclusion

Through our research I would like to conclude that, Sports training is a communication between coaches and athletes. The training tool is to help a coach organize information and explain certain aspects. An intuitive, direct, and real-time way with interactive graphical information gives more efficiency to the communication and reduces the misunderstanding. Motion training is one of the most important parts in Sports training. To help athletes do a right motion, the training tool is necessary to have ability to record the motion, and present it in an easier and more understandable way. Moreover, the recorded motion can be used for individual training without a coach, and for team training with coordinating to the same motion. The correction function is also necessary, because it gives a solution for explaining the wrong or right motion for a personal case.

We also get experience on implementing User Centered Design as a system development. We can conclude that, User Centered Design is a combination between designer's input and user's input. Users know special information in his area where he is a specialist, and the designer translates the information in to practical tools. On an ongoing project the designer would get closer and closer to the user's ideation, and can more easily see himself as a real user based on the rich information they get from user. This process grants the final design many functions to generate information. The different users can find out their own way to use such a product by selecting useful functions and getting information from different aspects.

REFERENCES

[1] King, R.C., D.G. McIlwraith, B. Lo, J. Pansiot, A.H. McGregor, and G.Z. Yang. "Body sensor networks for monitoring rowing technique." 2009 Body Sensor Networks (2009): 251–255.

[2] Gasson, S. "The reality of user-centered design." Journal of End User Computing 11, no. 4 (1999): 5–15.

[3] Churchill, J., E. von Hippel, and M. Sonnack. Lead User Project Handbook–A Practical Guide for Lead User Project Teams. Cambridge, Mass.: MIT Press, 2009.

[4] Concept2, The World's Best Rowing Machine http://www.concept2.com (2008-10-01)

[5]Abras, C., D. Maloney-Krichmar, and J. Preece. "User-centered design." Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications (2004).

[6] Xsens technology, 3D Motion Tracking http://www.xsens.com/en/general/xbus-kit?tab=1(2008-10-01)

[7] Arduino, Arduino Playground http://www.arduino.cc/playground/ (2008-10-01)

[8] Virtual Trainer , Sensory-Motor Systems Lab, ETH Zurich http://www.sms.mavt.ethz.ch/research/projects/m3/projects/virtual_trainer

[9] Schön, D. A. The Reflective Practitioner: How Professionals Think in Action. 1983.

Engineering 2, no. 2 (2010): 3083–3088.

[10] Michael, Boyle. "Functional Training for Sports". Human Kinetics, n.d. pp. 160 (2003) [11]Eagle Eye Digital Video, Motion Analysis & Video Timing http://www.eagleeyedv.com/category_s/483.htm (2008-10-01)

[12] Alessandro.F, et al "Dynamic models of team rowing for a virtual", The International Journal of Virtual Reality, 2009, 8(4):49-56

[13] Dickinson, I. "Position statement: in favour of (more) intelligence in the semantic UI" (n.d.)