Remote Impact - Shadowboxing over a Distance

Florian 'Floyd' Mueller
Distance Lab
Horizon Scotland
The Enterprise Park
Forres, Moray
IV36 2AB
UK
floyd@exertioninterfaces.com
& Interaction Design Group
The University of Melbourne
111 Barry St
Carlton, VIC 3010
Australia

Stefan Agamanolis
Distance Lab
Horizon Scotland
The Enterprise Park
Forres, Moray
IV36 2AB
UK
stefan@distancelab.org

Martin R. Gibbs
Interaction Design Group
The University of Melbourne
111 Barry St
Carlton, VIC 3010
Australia
martin.gibbs@unimelb.edu.au

Frank Vetere
Interaction Design Group
The University of Melbourne
111 Barry St
Carlton, VIC 3010
Australia
f.vetere@unimelb.edu.au

CHI 2008, April 5–10, 2008, Florence, Italy.
ACM 978-1-60558-012-8/08/04.

Abstract

People use a wide range of intensity when interacting with artifacts and one another, spanning from subtle to brute force. However, computer interfaces so far have mainly focused on interactions restrained to limited force and do not consider extreme physical and brutal interactions, such as those encountered in contact sports. We present an interactive demonstrator that aims to facilitate "Brute Force" activities to aid designers who want to leverage the physical and mental health benefits of such forceful interactions. Our prototype demonstrates that augmenting Brute Force with computing technology can be beneficial: unlike traditional contact sports experiences, it supports distributed participants. Our aim is to encourage designers to extend their supported interactions to include extreme forceful behaviors, which can contribute to general fitness and weight loss while at the same time allowing socializing in an entertaining sportive way.

Keywords

Blunt force, brute force, Exertion Interface, physical, tangible, videoconferencing, sports, active, exhausting, team spirit, team building, social, interaction.

ACM Classification Keywords

H5.2. Information Interfaces and presentation (e.g., HCI): User Interfaces.

Introduction

Sports are considered to have health and social benefits. From a physical health perspective, sports can contribute to a healthier body, reducing the risk of obesity, cardiovascular disease, diabetes, and more [12][13]. From a social and mental health viewpoint, sport is believed to teach social skills [14], encourage team-building and support individual growth and community development [15]. Some argue sport can foster social integration and personal enjoyment [16]. It should be noted that not all sports are the same or provide identical benefits. However, most of them involve participants voluntarily investing in physical exertion. In particular contact sports -sports in which the rules allow physical contact with other players- are often associated with intense physicality and brute force. Sport activities such as American football, ice hockey, wrestling and boxing are characterized by their explicit support for body collisions that facilitate brute force. Although these sports can be dangerous for the participants' health, they are very popular and many players enjoy participating, despite the risks [17].

A wide range of physicality, from subtle to brute force, is characteristic of the complexity of sport. Human computer interaction research has started to investigate physical interactions beyond mouse and keyboard, mainly to support participants' weight loss (for an overview, see [18]). These approaches, however, either measure everyday moderate body movements, such as step-count, or limit the interactions to specific (arm-) movements. It seems HCI has not yet investigated more extreme physical interactions, in particular brute force that is prevalent in contact sports, in order to utilize its benefits in computer-augmented experiences for users. By identifying characteristics and benefits of Brute Force in human-computer interactions, we hope to add extreme physical activities to the space HCI researchers consider when designing new experiences.

Remote Impact

Figure 1. Remote Impact

We have built a prototype of a Brute Force interface that supports two participants, located in two geographically different locations [Figure 1]. The gameplay of "Remote Impact" is as follows: The two remote players enter the identical interaction spaces. They are facing a sensitive playing area, on which the shadow of the remote person is projected. In addition, their own shadow is also displayed, in a different shade of grey. These shadows appear to be created by a light source behind the players, i.e. if the players get closer to the interaction area, their shadows increase in size. If the players face the interaction surface, it appears as if the other person is standing next to them, because the shadows show the silhouettes of two people. The players can also talk to and hear each other through a voice connection between the locations. Once the game starts, both players try to execute an impact on each other's shadow. Players can punch, kick, or throw their entire bodies against their projected opponent, and the system recognizes when there has been a hit or a miss. Players can dodge hits by ducking or moving out of the way, just as in traditional contact sports. More points are scored by hitting the opponent harder. The player with the most points wins the game.

Technical Implementation

Each station consists of a specially made impact area, consisting of two layers of foam and several layers of fabric. The foam is protected by a silky soft polyester lingerie fabric because its smoothness was required to minimize friction with the impact cover, which is made out of double stitched ripstop material, usually used in parachutes and therefore very strong and durable, but soft and lightweight. It is non-stretch, which was a requirement for our detection mechanism. Its white color also reflects the projection well. Our aim was to find a fabric that has a feeling to it that invites touching and getting in contact with.

A wooden frame is glued underneath the foam to hold the two surface fabrics in place, even under tension. To ensure a tight fit, we have sown elastics into the fabric. The impact of the user's body onto the surface is measured by detecting the deformation of the surface area, facilitated by the foam: upon impact, the non-stretch fabric exhibits pulling forces all the way to its sides, where it is held in place by 13 elastic bands, serving as springs. These elastics stretch when an impact occurs, and distribute the force based on the locations of the attachments, forming a grid of 42 impact locations, which we found sufficient considering the size of a fist impact. Attached at either end of the elastic bands are stretch sensors. Each stretch sensor consists of a flexible cylindrical cord with spade electrical fixings at each end. The sensors behave like variable resistors, the more they are stretched, the higher the resistance. We doubled each sensor in a sling-like fashion to increase the stretching action. Initially, we had used conventional surface material, which stretched, and therefore did not apply enough forces for the sensors to pick up, hence our decision to use the parachute material. We also trialed using the sensors themselves as pulling forces, but their sensitivity is at its highest when rarely stretched, hence when acting as a pulling source, the accuracy was limited.

Each sensor is connected to a data acquisition board that measures change in applied voltage via a simple circuitry sampled at a rate of 11 kHz. The resulting data is analyzed with a PC that performs normalization and signal analysis. Peaks above a certain threshold determine the location of the impact, and the height of the peak allows the calculation of the intensity, resulting in a three dimensional impact plane. The measured voltage is squared and a differential algorithm is applied before the results are squared again. This approach turned out to generate the most accurate results for both the location as well as the intensity of the impact. The differential approach results in a robust system that does not require complex calibrations before each new setup.

Advantages of our Approach

Other researchers have designed systems to detect impact on large surfaces [see for example [10]], but they are usually limited to interactions using hands or feet only and do not cover a large area. Our system supports very forceful interactions, protecting the user by the use of 15 cm thick foam. Furthermore, our stretch sensor approach allows for the detection of large impact areas, such as when a user throws their entire body onto the surface. If a user already has part of his/her body touching the area, additional hits are still detected, making our system multi-touch capable. The sensors are attached to the side of the foam, leaving the interaction area free from technical artifacts that could break during the forceful interaction. Unlike other systems that embed sensors directly into the surface area, our interaction space consisting of sturdy fabric and foam that can be hit and kicked ruthlessly.

Vision Detection

One major challenge we faced when designing for direct body interactions between remote participants is the cone-shape capture area of any camera that is used in videoconferencing systems. Systems that use videoconferencing components to allow for video interactions between their users such as [11] assume the actors stay a certain distance away from the projection screen, which is on the same level as the camera, capturing the local action. In contrast, in a body-to-body interaction, the user wants to, and is encouraged to, come as close as possible to the other person or their visual representation. However, the conical capturing area of the videoconferencing camera, or in fact any lens-based system, can capture only a limited area of the person once she/he gets closer, ultimately resulting in "no capture" once the user blocks all available light coming into the lens. Wide-angle lenses can only partly address the issue of not capturing enough of the interaction area; once a participant wants to touch certain parts on the projection surface, even the widest angle lens will not be able to "see" all interactions.

We therefore opted for an alternative approach to visualize the surface actions on the remote end: a camera mounted *behind* the user captures his/her actions. This captures all body movements, even when interacting with the surface area close-up. However, instead of distributing the video stream of the participant's back to the remote end, we use image analysis to detect the contours of the person and display his/her silhouette instead, reducing the unfamiliarity of videoconferencing a person's backside. We use a segmentation algorithm and distribute the generated vision analysis result over a UDP connection to the remote end. The user is able to determine the other person's body interactions in real-size, even when standing close to the projection surface or touching it. However, the silhouette functionality takes away any facial expressions which might contribute to the enjoyment and social interactions between the remote participants [3].

Related Work

Perhaps the earliest example of a networked Brute Force interface is the *Telephonic Arm Wrestling*, an arts installation created in 1986 [1]. Two players arm-wrestle a mechanical device that measures and applies force across a dedicated phone line. Recent instances of this approach are now available in public museums, where the players are connected via a videoconference, being able to arm-wrestle another person on the other side of the country [2].

Other researchers have investigated the convergence of computing technology and physical activities. Related work derived recently from a CSCW perspective, and the term *Computer Supported Cooperative Sports* [3] has been coined. To encompass social play, some use *Computer Supported Cooperative Play [4]*. *Long-Distance Sports* are described in [5], but the authors focus on commercial products that have mainly limited capability in terms of distributed interaction. The *Virtual Fitness Center* [6] uses exercise bicycles positioned in front of a video screen. The physical movements conducted on the exercise bicycle are used as input to modify the representation of 3D virtual environments from map information. Reversely, the map information affects the pedaling efforts. *Tug-of-War* can also support Brute Force; at the New York Hall of Science two teams of high-school students were involved in a tug-of-war 13 miles apart from each other [7]. More physically demanding interfaces are described in [8].

The advent of a new style of computer games with physical interactions has also arisen. The move by Nintendo away from a traditional game pad as input device for their latest console signals that the entertainment market might incorporate more bodily activities in the future: the console comes with a controller that contains accelerometers and infrared sensors. In order to hit the virtual tennis ball, the player uses the controller like a racquet [9].

Future Work

We are currently analyzing additional user data from an initial evaluation of participants playing the game. As some participants pointed out, the aspect of pain, often characteristic to Brute Force, is missing in the game, and we are therefore planning on extending the interactive surface by mounting a conductive fabric on top that can administer electric shocks if a player misses a hit to facilitate more intense and emotionally loaded play due to the more severe consequences of the player’s actions. Currently, there is not much risk in terms of personal harm involved in the game, but the addition of electric shocks could change this aspect, bringing our initial goal of providing a Brute Force experience a step closer.

Conclusion

Remote Impact is a "Sports over a Distance" game that provides a full body contact experience between geographically distant players. The game encourages extreme physical exertion and, unlike traditional games, it recognizes and registers intense brute force. We aimed to demonstrate that it is possible to design for an interaction that supports body-to-body-like interactions, overcoming general limitations of camera-based videoconferencing systems. By facilitating interactions similar to ones known from contact sports, our intention was to support a Brute Force experience for distributed players. Remote Impact includes a novel interactive surface that can span large areas and delivers impact location as well as intensity in a multi-touch environment.

We hope the physical intensity of the game contributes to general fitness and weight loss while at the same time allows socializing and creating new friendships over a distance in an entertaining sportive way. Furthermore, we hope our interactive exhibit can serve to begin a new dialogue around these ideas in the HCI community. Our aim is to excite other researchers and designers about the potential of using Brute Force in their applications.

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