BouldAR – Using Augmented Reality to Support Collaborative Boulder Training

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Abstract
Nowadays smartphones are ubiquitous and – to some extent – already used to support sports training, e.g. runners or bikers track their trip with a gps-enabled smartphone. But recent mobile technology has powerful processors that allow even more complex tasks like image or graphics processing. In this work we address the question on how mobile technology can be used for collaborative boulder training. More specifically, we present a mobile augmented reality application to support various parts of boulder training. The proposed approach also incorporates sharing and other social features. Thus our solution supports collaborative training by providing an intuitive way to create, share and define goals and challenges together with friends. Furthermore we propose a novel method of trackable generation for augmented reality. Synthetically generated images of climbing walls are used as trackables for real, existing walls.

Author Keywords
Augmented Reality; Gestural Interaction; Collaboration

ACM Classification Keywords
H5.1 [Information interfaces and presentation]: Multimedia Information Systems. - Artificial, augmented, and virtual realities

Introduction

Bouldering is a special variant of climbing near to the ground without a rope that emphasizes on few but difficult moves [1]. Although Bouldering was defined as a special discipline of climbing half a century ago it grews in popularity only recently. Due to this trend even specialized boulder gyms have newly been opened. In comparison to climbing bouldering is much more intensive because routes (called "problems") consist of only a few very hard moves. Bouldering can be performed individually because no belay partner is needed. Nevertheless, boulder training is often performed in groups and solving boulder problems can be perceived as a collaborative group experience as the following scenario shows.

Scenario

As usual Michael meets his friends in the climbing gym on Wednesday evening. After warming up they decide to focus on a special part of the wall and do some systematic training to improve certain skills (e.g. fixating small holds or undercuts). Therefore they define special sequences by pointing at holds that are "allowed" and then attempting to perform the defined problem sequence (see Figure 1). This kind of training is very helpful because individual strength, favorite movements and climbing styles will be avoided [2]. This leads to a much more varied training since every group member contributes his ideas, preferences and styles. Michael is very busy so he often misses the weekly training session with his friends. He tries to compensate this by doing individual training sessions on another day. Unfortunately, in these sessions Michael is usually not able to perform such a diverse training as in the group setting. He has problems to motivate himself and he often is dissatisfied with his training progress afterwards. It even gets worse when his friends tell him that they had defined interesting new problems during their last workout. Usually, Michael is not able to also give these problems a try since they are created on the fly and undocumented.

Figure 1: A group bouldering together defining new problems by pointing at "allowed" holds.

Systemboard Bouldertraining

One possibility for focused training in climbing and bouldering is systemboard training. A systemboard (e.g. the Moonboard[1]) is a special kind of climbing wall that has a standardized layout (size, slant, grid based hold structure, etc.) and hold sets. This layout allows an easy definition and documentation of different exercises, moves and problems by referencing the holds in a coordinate system (e.g. "B 12" in Fig. 3 (top)). In case of the Moonboard a small database with problems already exists. In this work we focus on the Moonboard since it can be seen as a de facto standard for systemboards. A systemboard allows a varied training that leads from

[1] http://www.moonclimbing.com/moonboard/

Figure 2: Computer Supported Collaborative Boulder Training using mobile augmented reality.

simple holding exercises to complex boulder problems. One example for a collaborative training method is advised climbing in which an advisor points on holds that the climber has to use next [2] that will be supported by the proposed system.

Ubiquitous games and computer augmented sports
The use of technology in sports training is nowadays a general practice to measure, analyze and document performance and progress especially in professional environments. Non- or semi-professionals also use training plans and diaries. To some extent mobile technology is already used to achieve this, e.g. runners or bikers who track their trips with gps-enabled smartphones. Computer Supported Collaborative Sports [7] as a research field in ubiquitous games and computer augmented sports is mainly driven by computer gaming research. From that perspective Reilly proposed a taxonomy for Computer-Augmented Sports Systems [5]. To our knowledge only few work on augmented reality (AR) has been done so far in sports technologies. *PingPongPlus* [3] by Ishii et al. is a seminal approach into this direction. In *PingPongPlus* a standard ping-pong table was equipped with additional sensors, and different visual and sound effects are augmented in order to allow a novel ping-pong playing experience.

The solution that is proposed in this paper uses AR and supports various dimensions of collaboration. Based on the previous considerations the contribution of this paper is twofolded: First, the question is addressed how technology can be used for collaborative bouldering training. More specifically we present a mobile augmented reality application to support various parts of bouldering training. The proposed approach also incorporates sharing and other social features for collaborative training.

Secondly, the paper contributes a novel method of trackable generation for augmented reality. The proposed approach uses synthetically generated images of climbing walls that are then used as trackables for real, existing walls.

Computer Supported Collaborative Training

The main goal for such a system is to create an intuitive and easy-to-use editor for boulder problems as well as a system that enables climbers to share their achievements and ideas on new boulder problems. By using AR it is possible to superimpose markers around specific holds over the camera display (see Figure 2). The viewport can be easily controlled by moving the mobile in front of the wall without the need of additional interface elements. In contrast to most other computer vision based AR approaches, the solution proposed in this paper uses huge portions of the environment as trackable markers, i.e. big parts or even the whole climbing wall. The system is designed to achieve three main requirements: (1) defining problems and goals, (2) managing a training diary and (3) collaboration and sharing of problems.

The creation of the new problems is rather simple. To mark a certain hold, the user only has to point the camera to the wall and touch the desired hold with his fingertip on the display. To compensate for the lack of precision on the small display the raster-based hold setup is used. If the user missed the intended hold she can quickly adjust the position of the marker by simple flicking gestures in each cardinal direction.

In order to keep track of the training progress a diary module is provided. First, one can simply log all unsuccessfully tried and successfully climbed problems in a training session. The user can share the completed

Figure 3: The real photography of the board (top) in contrast to the synthesized picture that is used as trackable (bottom).

training units with friends to inspire, compare, and motivate each other. Another useful functionality is the option to comment and subjectively judge on training units, session, and distinct boulder problems.

Users can get together in groups and share problems, achievements and climbing logs among each other. An achievement can be a predefined (hard) problem or a set of routes that needs to be completed within a particular timespan. The popular training technique "send me" [2] can be directly adopted in the proposed mobile augmented reality scenario. In this random skill practice a teammate is pointing the climber to random holds and thus forcing her to do unusual and unfamiliar movements. With this approach it is also possible to motivate (and control) climbing partners through online social interaction. Users can not only keep track of their own solved problems but also the ones of the climbing partners by sharing and discussing them online.

Another way to share a climbing experience can be through video. Feedback and video analyses are a well known concept in many sports to identify personal weaknesses [2]. In a training session the mobile can be used not only to visualize problems but to video capture the climbing performance.

The proposed concept of Computer Supported Collaborative Training uses a multi-dimensional approach of computer supported collaborations. On the one hand individual training that was remotely created in asynchronous collaboration with others and on the other hand co-located collaboration in synchronous training sessions when an advisor guides the climber using the application. While the diary functionality primarily focuses on individual training the problem and goal definition feature is optimally suited for sharing.

Synthetic images and huge trackables

Natural feature tracking is getting the state-of-the-art technology in AR [6]. In contrast to the usual use of AR, not small printable markers are used but the whole wall as a huge trackable. The advantage of this is, that large parts of the marker are in the viewfield of the camera at any time. This even means that the occlusion by the climber on the wall is negligible. After recognizing the trackable, the application renders the camera preview in the display and superimposes round marks over specific holds (see Figure 4 (bottom)).

The first prototype used an actual photo of the climbing wall. Lense and perspective distortion was removed to obtain a picture of the walls with the holds aligned in an uniform grid, which resulted in a satisfying recognition. The fact that the Moonboard and the hold sets are standardized offers the opportunity to automate the process of the trackable creation in a way, that pictures of the actual board are synthesized, based on the knowledge of the current hold configuration and the dimensions of the board. This has the advantage that gym operators and wall owners could easily set up their board in a configuration tool by choosing the predefined hold sets instead of taking a picture of the board and manually preprocessing it (remove distortions, adjust lighting, etc.) every time the configuration changes.

To establish an automated trackable creation system it was necessary to take photos of a large amount of single holds, which were then cropped and stored in a database. Thereby it is now easy to create a picture of the wall by simply aligning the holds in a predefined grid which is in accordance to the measurements of the actual systemboard. To obtain a good trackable that ensures robust tracking, it is only necessary to take a photo of the

Figure 4: Screenshots: problem list (top), marked holds in AR view (bottom).

systemboard when no holds are mounted. To increase the number of natural features it is possible to add a high contrast pattern to the background of the climbing wall (e.g. an artistic climbing image or a logo - see Figure 6).

This details are used as background for future creation of the synthesized pictures of the wall. An example for a synthesized picture can be seen in Figure 3. By visually inspecting both images, one would assume that the synthesized image is not sufficiently similar to the real photography of the board. Nevertheless the synthesized picture works very well as trackable and provides a robust recognition of the climbing wall.

During development some issues arised according to the number of natural features contained in the marker. The photo as well as the synthesized picture of the climbing wall do not provide a large number of natural features. To increase the number of natural features it is possible to add a high contrast pattern to the background of the climbing wall (e.g. an artistic climbing image or a logo - see Figure 6). This leads to an improved recognition of the trackable.

Another problem are the different plan views gained by different viewpoints. Because of the fact that the holds are three-dimensional they also have different plan views depending of the viewpoint, resulting in different views of the whole board. This might lead to an unstable tracking. During development and pilot testing we observed that the tracking could not be initiated from every position. However, when starting from certing spots and even moving to these position, the tracking kept constantly robust. The area which includes those starting points is called initial recognition area (see Figure 5).

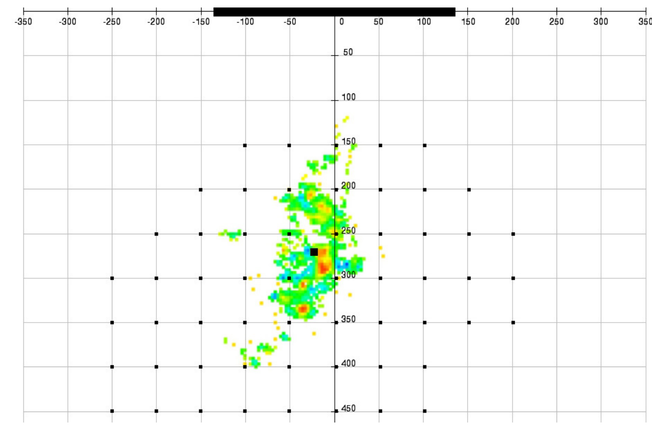

Figure 5: Heatmap showing the hot spots of the users locations in front of the systemboard (black bar). Black dots illustrate the initial recognition area. Scales are in cm.

Implementation

The system was implemented for the Android platform using the Qualcomm Vuforia SDK for Augmented Reality[2]. A Samsung Galaxy S was used as development device. As mentioned above, synthetic images that are composed of background and holds images are used as trackables to achieve more flexibility. The rating system within the Vuforia SDK rated this solution as good as the photo of the wall.

Initial Study and Feedback

Six subjects (three female, age: $M = 25$) that were recruited in the climbing gym participated in a half an hour long trial session. The participants were asked to perform two tasks; that is, creating new problems and describing existing ones to the interviewer. The creation was performed with the help of unmarked printed wall

[2]http://developer.qualcomm.com/dev/augmented-reality

Figure 6: A mockup of a possible addition to the background of the climbing wall.

templates, respectively the application. In the second task the participants had to describe boulder problems based on printouts and also the smartphone.

The participants were able to easily perform the tasks. In the problem describing task the participants overestimated the complexity of the smartphone case and underestimated the printout use. Five out of six users expected that the smartphone usage would be harder and that the printout would be easier to use than it was actually experienced. In the second task both smartphone and paper based route creation were judged easy to use In this task the smartphone application was considered more easy than the paper version. Five out of six people would prefer the smartphone application over the paper based solution. One participant requested the feature to use the application not only with specific systemboards but with arbitrary climbing walls in a gym.

Conclusions and Outlook

In this work we investigated a mobile augmented reality application for collaborative boulder training. In order to support collaborative climbing training we developed a mobile augmented reality application to define, document and share boulder problems. With this approach we aim to support a more collaborative training by providing and intuitive way to create, share and define goals and challenges together with friends. The proposed technical solution makes use of synthetic images that are used as trackables. This approach allows a flexible and robust solution that is very well suited in a climbing gym scenario.

The initial user feedback is promising. Nevertheless the concepts of collaborative training needs to be explored more in detail in future work. We aim to deploy this application to the Android market and invite all owners and users of such systemboards to use the app to share their problems and investigate their experiences. As a next step, the system will be evaluated in a more extensive usability test. Currently, this work is focused on the Moonboard but it can be easily extended to every systemboard as well as arbitrary boulder walls. The requested support of arbitrary walls might be supported by using the Snap-To-Feature interaction method [4] that might be used detect holds (select the nearest image feature). But also other application areas for mobile AR based training need to be considered. This will be developed and investigated more in detail in future versions.

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