Conference papers

School of Computer Science

2005

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Recommended Citation

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The AMPERE Algorithm – Area-based Masking with the PERformance Equation

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Abstract

This paper is concerned with the employment of an autonomous and intelligent agent within the context of a 3-dimensional virtual environment. As the agent is immersed within the virtual environment, it empowers the 3D world with mechanisms to adjust itself to the specific needs of its user. Therefore, the agent serves as a middle layer between user and the environment. The 3-dimensional environment thus evolved into an intelligent user interface.

We track user's motion within this environment and present an equation upon which the agent classifies the user's performance. Based upon this performance value, the agent autonomously determines if the user would benefit form system navigational support.

The performance equation is based on an area-based mask that is applied on the trajectory image of the user's movements. Within this paper we discuss the effects of applying different masks onto the trajectory image. We evaluate, why the actual shape of the mask is not as crucial to the performance measure as one might anticipate.

Assessing Performance

Much research has addressed navigational issues within 3D worlds for explorational tasks. Usually, rather heavy-weight methodologies like Bayesian networks are employed in order to assess the user's performance within these virtual environments, like Sas's attempt to employ an agent in order to recognise a user's movement pattern (Sas 2004). Within the Agent Chameleon project (O'Hare *et al.* 2003) we adopt this idea of tracking a user's motion within a 3D environment by an intelligent and autonomous agent. We use this data to generate a measure upon which the navigational agent will determine whether the user needs help. Contrary to previous research, we offer help *indirectly* by adjusting the environment itself rather than communicating *directly* with the user. This is to increase the user's sense of immersion within the environment.

In (Schön *et al.* 2004) we introduced the concept of generating a performance value, which is based upon an area-based mask. By doing so, we obtained a reliable indication of the user's performance within the environment. Such an

approach was previously introduced by Foster et.al. (Foster, Nixon, & Prugel-Bennet 2001) to recognise gait patterns in extracted silhouettes of movement sequences. Figure 1 presents the algorithm which leads to the performance value (PV), see figure 1. First, we generate a trajectory image of the user's movement within the environment, as presented in figure 1(a). The task within this experiment was to find a certain shape within the environment. Next, we apply the area-based mask, see figure 1(b). In order to retrieve a first input to the performance equation, we divide the unmasked area via the inclusion of several lines. The arithmetic average between the intersections of the user's trail and these test lines are computed, see figure 1(c). The first input to the performance equation is the average amount of intersections within this area $i_w = \frac{1}{s}\sum_{l=1}^{s} x_l$; with $s > 0$. Afterwards, the area mask is inverted and the same procedure is applied on the previously masked are, see figure 1(d). This serves as a second input to the performance equation: $i_b = \frac{1}{v}\sum_{l=1}^{v} x_l$ with $v = s + 1$. Time is an important issue when considering user performance and efficiency. We therefore define the following equation between the two average amounts i_w and i_b in relation to the time value t: $p = i_w i_b / t$. Empiric tests proved that four performance categories (*good, moderate, bad* and *very bad*) serve well to classify user's performances. The PV lies between 0.0 and 1.0. The subject in figure 1(a) gained a PV of 0.21, which classifies her as a *moderate* user.

Discussing the Masking Approach

The mask in the example above was of a horizontal shape. The following section verifies our choice in the mask's shape, that comprises goal and start point. However, a vertical mask would have been just as intuitive a choice as the horizontal mask we have employed. It is natural to assume that the performance value changes with the choice of mask that is utilised. Therefore, we applied a different, vertical mask on our data set and compared the results with those of the horizontal mask. Surprisingly, the general distribution of performance values among the set of user data did not change. Most subjects were classified with the same PV as in the previous experiment employing a horizontal mask.

However, one of the subjects fell out of this general result. Contrary to the other subjects, this person was less explorative within the environment, ass seen in figure 2(a). Most

(a) Trajectory Image   (b) Area-Based Mask   (c) Retrieving Intersections   (d) Inverting Mask
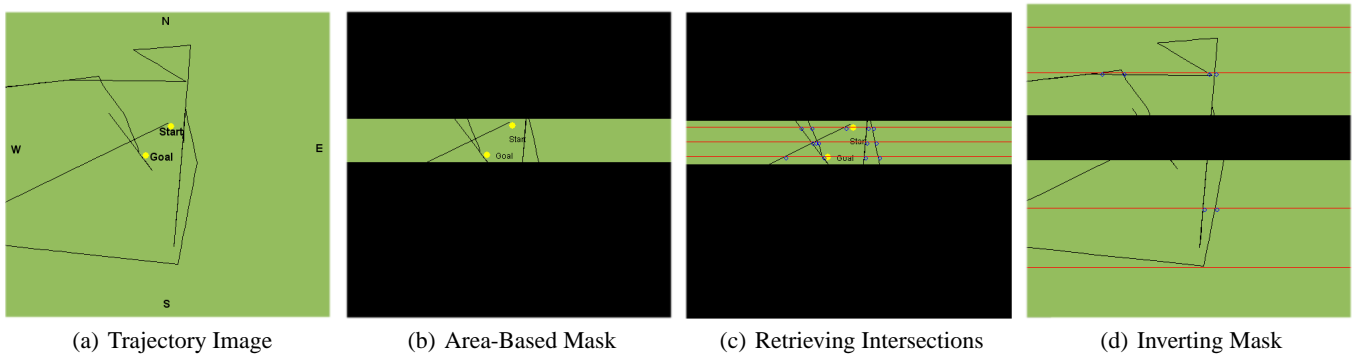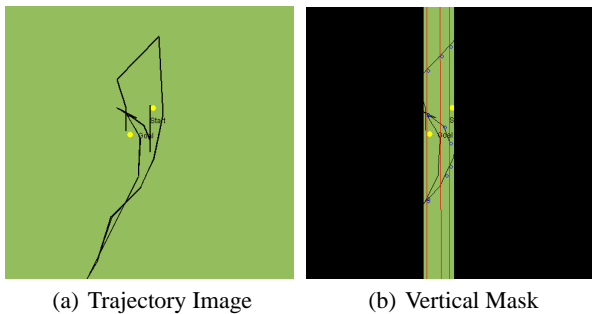
Figure 1: Graphical Presentation of the Masking Process on a moderate Performance

of his actions are focused on the area that is enclosed by the vertical mask, see figure 2(b). The horizontal mask calculated a PV of 0.2, which renders him as a *moderate* user, whereas the vertical mask classifies him as a *good* user, with a PV of 0.03. This result might lead to the conclusion that the shape of the mask depends on the explorational attitude of each user. As the agent is unable to predict such behaviour, the mask would proof not generally applicable. However, this performance value only represents offline evaluation. In the experimental scenario, the agent accumulates the performance measure online for each time step.

(a) Trajectory Image   (b) Vertical Mask

As the shape of the horizontal and vertical masks do not result in the same performance value, the next suggestion would be to combine the two masks. This would result in a mask that forms a square around the start and goal point and excludes the rest of the environment. However, we do not commission the use of such a mask as it heavily restricts the area. This forces the performance equation into an unbalance state. In order to compensate this, the components that constitute the performance equation would need to be weighted. Considering the relatively small benefit from these adjustments and the already high accuracy of the performance equation with the presented type of mask, we do not recommend this approach.

Conclusion

Within this paper we have described an area-based masking approach in order to gain information about user performances within a 3-dimensional environment. We described

our performance equation and discussed different kinds of area-based masks in order to generate a performance value. Interestingly, changing the shape of the mask did not have a decisive impact on the classification of the user performance. Limitations of this approach are that the agent has to have knowledge about the dimensions of the environment. The layout of rooms, doors and objects is not considered here. Further research has to determine whether it is beneficial for the overall performance evaluation or if it occupies too much computational resources without the benefit of a higher level of accuracy.

Acknowledgement

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