Reducing Location Overhead in Educational Geogames

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Locomotion in location-based games

In location-based games, the player's physical position determines which game actions are available. As a consequence, locomotion between places of game play may consume a sizeable fraction of playing time. We present first results from an empirical study of player locomotion in an educational geogame.

The players of location-based games move in urban or natural environments using mobile devices to access spatial data and to solve place-related tasks. These games are also known as *geogames* (Schlieder et al. 2006). Most player actions in geogames may only take place at certain places in the geographic environment. This is a defining feature and provides the rationale for using them in educational contexts (Klopfer, 2008, de Freitas et al., 2012).

A geogame creates incentives to visit places which students probably would not visit otherwise. Furthermore, it motivates them to engage in place-related learning activities such as documenting a geofeature or analyzing spatial relationships (Schaal et al. 2012). As a consequence, the players move between places during the learning experience, often spending considerable time on locomotion. While this type of physical activity is generally welcome – and an integral part of the classical field trip – it should not dominate the learning process (Kremer et al. 2013).

We were confronted with the issue of locomotion overhead while designing a location-based game for the purpose of biodiversity education, the *FVsimulation* geogame. Its game mechanics combines a simulation of biodiversity with location-based tasks (Fig. 1). First data from GPS tracks and activity logs revealed that players moved very differently on the game fields,

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some taking optimal paths, others seemingly wasting time by reiterating path segments.

FVsimulation belongs to the class of relocatable geogames. The game engine implements a framework which permits to restrict game actions to specific places of game play. In a first step, the organizer of the game, typically a teacher, has to define these places. He or she has considerable degrees of freedom in doing so. The game tasks where the player interacts with the simulation can easily be bound to different places (Fig. 1 left). Other tasks, however, are tied to specific places in the geographic environment. An example is the task of determining distances between trees in a fruit plantation (Fig. 1 right).

Figure 1. Interface of the location-based simulation game

In choosing the places of game play, the teacher acts as a co-designer of the game. Fig. 2a shows a rather small game field with 6 places of game play. Obviously, locomotion time depends on the design of the spatial layout of the places: a larger spatial coverage implies longer paths, and longer locomotion times. Topology also matters. The preferred path structure of a game field may be a linear chain or a tree or some graph containing cycles.

Figure 2. (a) Game field with 6 places of game play **(b)** GPS tracks of players

The game mechanics of *FVsimulation* requires the players to complete each task exactly once. In other words, on a game field of *n* places of game play, each of the *n* places has to be visited. The game mechanics, however, does not ask for a particular visit order neither does it prevent the players from revisiting places or walking on path segments which they have used before. Locomotion overhead is determined by the order in which the player decides to visit the places associated with learning tasks.

An example illustrates the issue. The GPS track data (Fig. 2b) show that players access and leave the game field (Fig. 2a) via place 2. However, many players choose to perform their first task at a different place. One team of players, for instance, choose to work on the tasks in the order 3-7-5-0-1-2. It turns out that the chosen task sequence produces considerable locomotion overhead. The chosen action sequence expands into the rather long path 2-7-5-**3**-5-**7-5**-3-**0**-3-**1**-3-5-7-**2**. This raises two related questions, the first two of which we addressed in an empirical study: Do suboptimal paths occur frequently? What spatial planning strategy could explain suboptimal paths?

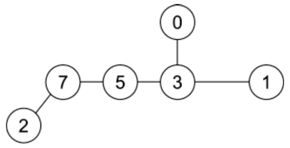
Empirical findings from the case studies

A total of 64 games were played by high students aged 10-16 on a playing field located near Filderstadt, Germany (Table 1, path network A). Additionally, a second data set of 39 games was collected at another geographic location, Eichstädt, Germany, with a comparable group of student players (Table 1, path network B). Note that the structure of the path networks differs. Network B is linear while Network A is structured as a tree, although with a single branching only. Both networks resulted from the choice of places made by teachers or education researchers with local knowledge.

An analysis of the georeferenced activity log reveals that suboptimal paths are quite frequent (Table 1). The length of an optimal path (it needs not be unique) depends on the entry and exit nodes of the network. Place network A is entered and left at node 2 while place network B can be entered or left at node 8 or 2. For path network A, optimal paths were chosen only in 5 of the 64 games. Most players chose an activity sequence which used 6 segments more on the path network than an optimal solution. The result is less pronounced for path network B, though clearly visible. Most games, 25 in total, are played on suboptimal paths, only 14 follow one of the two optimal paths.

Analysis and discussion

The finding that players frequently choose action sequences associated with suboptimal paths is surprising because the game mechanics puts no strategic advantage on any sequence of activities. On the other hand, players have an interest to minimize locomotion, if not for sheer laziness, then for maximizing the time available for solving the place-related tasks. What is it that makes players choose suboptimal action sequences?

path network A		
		
excess path segments	example task sequence	frequency
0 = optimal	2-7-5-3-0-1	5
+2	5-7-3-0-1-2	2
+4	3-7-5-0-1-2	10
+6	1-3-7-5-2-0	43
+10 = worst	3-5-7-1-2-0	4

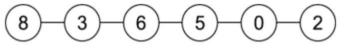
path network B		
		
excess path segments	example task sequence	frequency
0 = optimal	8-3-6-5-0-2	14
+2	0-2-5-6-3-8	3
+4	6-3-8-5-0-2	9
+5	3-6-5-0-2-8	9
+6	6-5-3-8-0-2	2
+7	6-3-5-0-2-8	1
+10 = worst	5-0-3-6-2-8	1

Table 1. Frequency of suboptimal paths in two path networks

It is known that human problem solvers rely on a mixture of spatial strategies for path planning (MacGregor & al. 2006, Tenbrink & Wiener 2009). Some of the strategies are problem-specific, like the convex-hull strategy for travelling salesperson problems, others apply to a wider range of problems including path planning in networks similar to those of our two data sets. Among the universal strategies, the nearest-place-first strategy seems to be most widely adopted.

Consider a population of players most of which adopt the nearest-place-first strategy as their dominant approach to spatial search. For the path network A, which has the entry and exit at node 2, this strategy would produce the optimal activity sequence 2-7-5-3-0-1. As a consequence, we should observe a majority of optimal paths, which is not the case, as we have seen. Likewise, the strategy would produce an optimal action sequence on the linear path network B, for instance, with entry node 8 the sequence 8-3-6-5-0-2. Again, this not what the data shows.

Some additional strategy must be effective. A possible candidate is the strategy to avoid places at which other players are already engaged in game activities. While in principle many players can work at the same time on the same task, this seems to be the exception rather than the rule. For path network A, for instance, one finds at every node (with the exception of the entry node) most of the time only a single player. Players tend to avoid crowding at the places of game play.

Conclusions

In many if not most learning scenarios it is desirable that the players of an educational geogame start and finish playing at about the same time. Playing time spent on locomotion between places cannot be devoted to place-related learning activities. Our data shows that a major source of locomotion overhead is linked to suboptimal choices of place-related action sequences. Surprisingly, a majority of players were found to make these suboptimal spatial decisions. It seems that players tend to avoid crowded places where other players are already engaged in learning tasks. Future research will study the effect of network topology on locomotion overhead.

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