Analysis of group movement patterns from an educational perspective

PhD Proposal

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1. Introduction

With the remarkable advancements in location- acquisition technologies, such as global positioning systems (GPSs), a large amount of spatio-temporal data can be collected in the form of trajectories (Zhu et al., 2019). The acquired trajectory data allow us to better understand the movement pattern and behavior of moving objects. In recent years, the attention paid to analyze behaviors of group members to discover their movement patterns. Some types of group movement patterns have been proposed in several studies, such as convey (Jeung et al., 2010), flock (Gudmundsson et al., 2006), leadership (Andersson et al., 2007). Identifying a group of objects moving together for a certain period of time can illustrate the group behavior, social interaction and the role of each member.

Although the study of group movement patterns has been extensively researched, most research to date focused on adult movement (Feuerhake and Sester, 2013; Wei eta l., 2015; Zhu et al., 2019). Thus, we argue that the current state doesn't cover all existing patterns, as group movement patterns of children aged between 9 - 12 years for instance haven't been well investigated. Investigating children's movement behavior can reveal how they behave in a collaborative navigation and the role of each student in the group such as leader or follower. Furthermore, it can assess their movement competence and identify hidden patterns in spatio-temporal data.

Furthermore, previous research relied solely on trajectories in detecting group movement patterns. In this study we will also utilize behavioral data which include user interaction with the data collection tool (our proposed geogame) and the way of distributing responsibilities. We believe that utilizing such behavioral data can leverage the pattern detection process and help us to further understand students behaviors.

In this study we want to investigate *how group navigation behavior of children can be interpreted based on trajectories and behavioral data.* For this purpose, our work involves designing and developing a collaborative geogame as a data collection tool. The expected contribution of this study is twofold. First, we will provide an overview of possible movement patterns of children. Second, a processing algorithm that automates the operation of identifying spatio-temporal patterns.

2. Related Work

Group movement pattern

Exploring groups of objects that move together for a certain period of time is an important research to provide insight regarding the behavior of moving objects. Three aspects play a major role in distinguishing group patterns: group shape, continuity of the group and whether group members are variable throughout the lifespan of the pattern (Tsai et al., 2009). Some types of group movement patterns have been proposed in several studies. Gudmundsson et al. (2006) proposed flock pattern, where a group of objects move together within a specified radius for a certain time period. When a flock is stationary then it's called a meeting pattern. Direction of movement is crucial in detecting some spatio-temporal patterns such as leadership pattern. Laube et al. (2005) defined leadership pattern as an extension of flock pattern with the difference that one group member shows constancy over the previous timestamps. Further definition of leadership made by Andersson et al. (2007) who defined a leader as an entity that doesn't follow any of the group members and is followed by a number of members for a duration of time.

Movement pattern mining

Several data mining techniques were developed to identify different types of behavior from spatio-temporal data. For instance, the clustering method takes a set of data objects and divides them into groups called (clusters) in a way that each group consists of similar objects (Jain et al., 1999). Density-based approach is one type of top-down clustering algorithm. The DBSCAN (Ester et al., 1996) is the most used algorithm for point based clustering. Lu et al. (2015) utilized a modified version of the DBSCAN algorithm to detect clusters in urban areas. Another density-based algorithm is HDBSCAN which is developed based on DBSCAN but works better in finding clusters of varying densities as it only requires one user input parameter ebsilon (Wang and Govindarasu, 2018).

Collaborative game design

When designing a collaborative game, there are several guidelines and features that need to be considered. Wendel and Konert (2016) discussed three core steps in order to design a multiplayer game. First, defining the target group and the characteristics of the game. Second, deciding how many players are supposed to play the game and whether they participate asynchronously or simultaneously. Finally, considering to what extent the game will depend on hardware and network infrastructure. The latter step could cause a latency problem which is a core issue when a game is intended to be played using the internet rather than a local network. To avoid latency problems, it should be determined from the beginning how much the game relies on real-time execution (Armitage et al., 2006). Furthermore, there are some characteristics that have an impact on game design that include the number of players, matchmaking, influence of communication on gameplay, social issues (Wendel and Konert, 2016) . Weissker et al. (2020) discussed the way of distributing responsibilities among participating users as a core issue of collaborative game design.

3. Research Questions and Objectives

The main objective of this dissertation is to interpret group navigation behavior of children based on trajectories and behavioral data.

The following research questions are defined:

- RQ 1 Which spatio-temporal movement patterns are relevant to educational settings ?
    - RQ 1.1 Which patterns in literature are relevant to educational settings ?
    - RQ 1.2 Which patterns can be identified by experts in education ?

  Although the literature identifies different group movement patterns, We argue that the current state of patterns doesn't cover all existing movement behaviors, for instance the ones related to educational settings where school students are the target group.

- RQ 2 How can collaboration mode be realized in geogame in terms of design and characteristics?
    - RQ 2.1 What features make geogame support collaboration in spatio-temporal problem solving ?
    - RQ 2.2 What are possible spatial collaborative tasks and ways of their distribution ?

  We collect possible features of multiplayer game design and find out what collaborative tasks fit in educational settings. Findings will frame the guidelines and criteria to develop a collaborative geogame.

- RQ 3 How can group movement patterns of spatio-temporal data be identified in educational settings ?
    - RQ 3.1 Which algorithms are suitable for detecting movement patterns through trajectories and behavioral data ?
    - RQ 3.2 How accurate are the selected algorithms in identifying movement patterns ?

  We select and evaluate a set of algorithms that can identify types of movement patterns relevant to educational settings in spatio-temporal data.

- RQ 4 What role does game design play on group movement patterns ?
    - RQ 4.1 Can game design suggest a certain movement behavior ?

  We assume that movement behavior of a group may differ based on game settings (e.g., type of distributing responsibilities)

4. Methods and Work Packages

WP1: Exploring group movement patterns

The goal of this work package is to provide an overview of movement patterns that are relevant to educational settings. This goal is approached via conducting a literature review followed by a focus group. From the literature review we can identify a set of existing spatio-temporal group patterns with distinguishing patterns that are affected by social interactions of group members. As group navigation behavior of children hasn't been well investigated, we argue that there are some uncovered patterns that we can identify with the help of the focus group. The focus group consists of school teachers who have a profound experience in dealing with students. As a preparation for the focus group, this work package will include conducting a pilot study where our proposed geogame will be used as a data collection tool by school students who will participate in groups to resolve spatial tasks. The resulting trajectories of the pilot study will be shown for the focus group to identify possible movement patterns and verify patterns found in literature review.

WP2: System and technical design

The main contributions of this package are firstly, to design and develop a geogame that supports multiplayer mode in solving spatial-temporal tasks. Secondly, describing the challenges in requirement analysis and overall implementation of a geogame that support multiplayer mode. The task types, tasks distributions and collaboration features utilized in the proposed geogame are based on literature review (Wendel and Konert, 2016; Weissker et al., 2020; Weissker et al., 2021). The geogame can collect detailed data of user movement that include user's location (geographic coordinates), time, view direction and behavioral data. The proposed geogame will be utilized in WP1, WP3 and WP4 as a data collection tool.

WP3: Mining group movement patterns

To facilitate the process of choosing an algorithm for detecting movement patterns, it's helpful to first identify expected patterns that may exist in data in the form of behavior (Jeung et al., 2010). This work package aims to find suitable algorithms capable of automatic detection of the set of movement patterns identified in WP1. Spatio-temporal data will be collected in a study experiment where data collection tool is our proposed geogame developed in WP2 and participants are primary school students. Selected algorithms will be applied on collected data and outcome patterns of each game design will be evaluated against ground truth using precision and recall method.

WP4: Collaboration behavior and game settings

The aim of this package is to investigate the role of game settings on group movement patterns. We will analyze the experiment data to check whether there is a correlation between game

settings (way of distributing responsibilities) and resulting movement patterns. The results will reveal whether game settings can suggest a certain movement behavior to a group of users. Furthermore, our processing algorithm developed in WP3 will be evaluated in identifying movement patterns when the method of distributing responsibilities doesn't suggest a specific behavior.

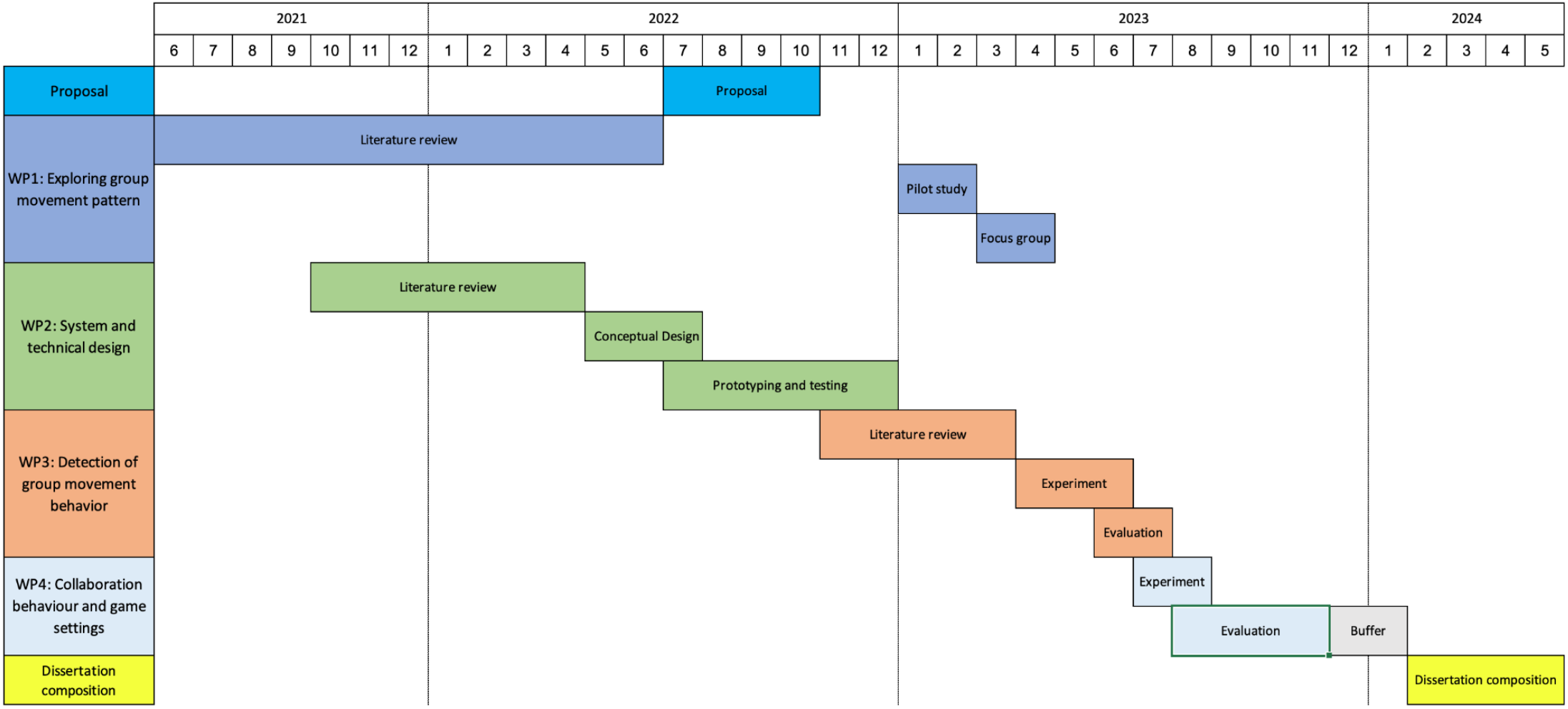
5. Expected Results and Evaluation

The following are the expected results of the dissertation:

a. Overview of possible group navigation patterns of children
b. Technical design and implementation of an educational geogame that support collaboration mode
c. A processing algorithm to automate the operation of identifying spatio-temporal patterns
d. Overview of the role of game design on group movement behavior

The evaluation process of the work is divided into two parts. First, our proposed geogame will be evaluated against the defined requirements, including its ability to support collaboration mode and collect data of a group of players simultaneously. Second, the chosen algorithms for detecting types of movement patterns will be applied on collected data then evaluated against ground truth to identify their efficiency using precision and recall method.

Timeline


2021
2022
2023
2024
6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5
Proposal
Proposal
WP1: Exploring group movement pattern
Literature review
Pilot study
Focus group
WP2: System and technical design
Literature review
Conceptual Design
Prototyping and testing
WP3: Detection of group movement behavior
Literature review
Experiment
Evaluation
WP4: Collaboration behaviour and game settings
Experiment
Evaluation
Buffer
Dissertation composition
Dissertation composition

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