A SOLUTION TO OPERATION CONFLICT IN COLLABORATIVE SPATIAL DECISION SUPPORT SYSTEM

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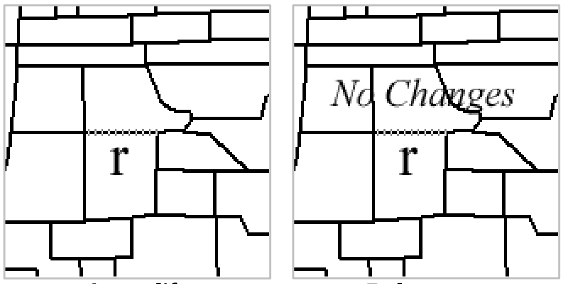
ABSTRACT:

Collaboration based on GIS provides a spatially referenced negotiation environment for decision makers. Among the collaboration process, the operations of the system users may conflict. The existing solutions to operation conflict are essentially based on the time the operations occur. It doesn't consider the characteristics of the operations and the collaborative relationships between the system users. This paper analyzes the types of operation conflict and the cooperative actions of the users in Collaborative Spatial Decision Support applications. And it introduces Speech-Act Theory (SAT) to describe those cooperative actions. Eventually, the mapping relationships between the operation conflict and the cooperative actions are established to solve the operation conflict problems. Experiments demonstrate that the method is practical.

1. INTRODUCTION

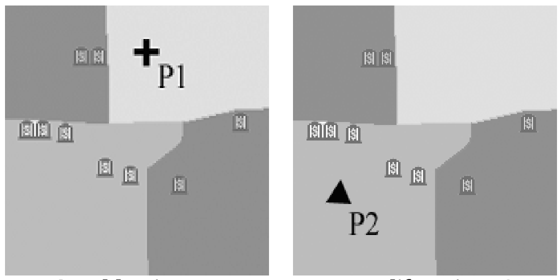
The Internet-based computer supported cooperative work (CSCW) concepts and related technologies have been increasingly integrated in many application fields to support collaborative work in distributed work environments, through which collaboration among group of people located at various geographical locations can be realized (Li and Coleman, 2002). Collaborative Spatial Decision Support System (SDSS) (Chen et al., 2004; Alan and Isaac, 2004) is among these potential fields. Recently, it has been widely applied in E-government and office automation. More and more local authorities was getting involved in the development of G-CSCW systems, such as GIS support for distributed group-work in regional planning (Rachel et al, 1997), the land subdivision system in the urban planning field (Jiang and Chen, 2002), collaborative spatial decision-making in site selection (Piotr et al, 1997), collaborative emergency management with multimodal GIS (Sven et al., 2003), etc.

In such applications, experts located in different places analyze, discuss spatial problems, and select decision schemes via collaborative SDSS platform. Because these experts have different backgrounds and interests, spatial discrepancy usually exists among their perspectives. And their operation events may conflict. Figure 1 describes several scenes of operation conflict. In figure 1-a, user B is browsing the map while user A is modifying the attributes of road r in that area. The conflict represents that user B cannot get the updated information in real time. In figure 1-b, both of point P1 and P2 locate in the view of user A and B. While A is adding point P1 to the dataset, B is modifying the attributes of point P2. The result is that both A and B couldn't get the updated data in real time. In figure 1-c, A and B are modifying two different attributes of object l at the same time. The conflict exists how to avoid the lost of information and coordinate the different operation results on the same objects.



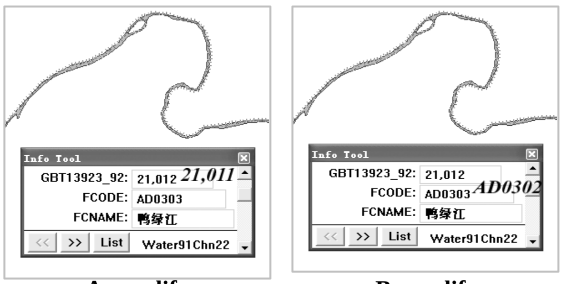
A: modify **B: browse**

(a)



A: add point P1 **B: modify point P2**

(b)



A: modify **B: modify**

(c)

Figure 1. Operation conflict problems

In a word, operations conflict makes great effects on the collaborators. The effects include two aspects, non-visualization of changes (figure 1-a, figure 1-b) and the lost of information (figure 1-c). To solve the operation conflict problem in collaborative systems, there is a need of an appropriate solution.

This paper is organized as follows. Section 2 reviews the related approaches. Section 3 analyses the types of operation events and operation conflict, and presents a SAT-based solution to operation conflict. The 4th section is the experiments. And some conclusions are given in the last section.

2. PREVIOUS APPROACHES AND PROBLEMS

Operation conflict is one of the most important research topics of multi-users system, which was also called as concurrency control. In the past years, many methods, such as serialization, locking, timestamp, and operations transformation, were brought forward to avoid inconsistency caused by concurrent operations. The former three methods were mainly designed for non-communication systems. They could well keep the consistency of data with simple algorithm, which essence is to define the operation sequence according to the time the operations occur. But these methods have some strict constrains. For example, there is only one user who can operate an object at a specific point of time. The operation transformation method was presented by Ellis while he was researching one real-time cooperative authoring system named GROVE (Ellis and Gibbs, 1989). This method defines the partial sequences on operation sets by analyzing the relationships among operations. It greatly reduces the number of operations to order. However, in G-CSCW system, the solution to operation conflict couldn't simply depend on the order that the operation events occur. It also relates to the relationships among the system users and the characteristics of the operations. Most of the methods don't consider the two factors.

Speech-Act Theory (SAT) was firstly put forward by philosopher J.L.Austin in the end of 1930s. It was mainly used for solving the cooperative problems in computer science. Winograd used SAT to develop coordinator supporting communication between colleagues and described the cooperative process among users with 5 illocutionary points proposed by Searle (Winograd, 1986). Mario related SAT with the cooperative mode between agents. According to SAT, he classified cooperative actions between agents into five kinds: informing, activating, obstructing, guaranteeing and interrogating. Different action has different scope of activity, namely prescriptive, alternative and flexible and different message direction, namely unilateral, bilateral and ultilateral. Then the cooperative modes among agents could be decided by mapping between cooperative actions and the scope of activity and the direction of message.

Winograd and Mario have studied the cooperative actions between peoples. Winograd could describe the cooperative action of people. But he couldn't answer how people collaborate. Mario investigated how to get the cooperative mode according to the cooperative action of agents. But he didn't employ the cooperative action to solve the practical problems, such as operation conflict. The purpose of this paper is to establish the mapping between types of operation conflict and cooperative actions, and solve the problem of operation conflict according to the cooperation between people. Figure 2 is the comparison of the methods of Winograd and Mario and the method presented by this paper.

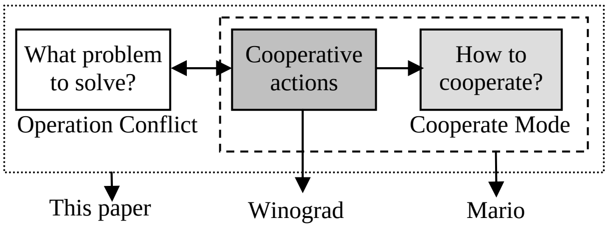


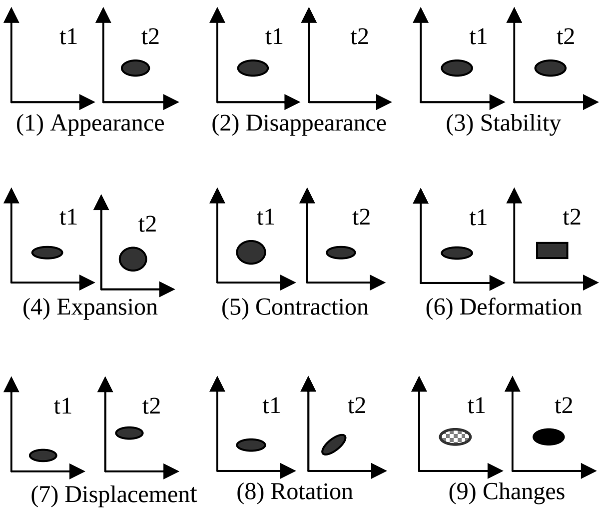
Figure 2. The comparison of the research range of Winograd, Mario and this paper

3. METHODS FOR SOLVING OPERATION CONFLICT BASED ON SAT THEORY

The method based on SAT theory includes four parts. First, operation events in G-CSCW are defined according to the changes of spatiotemporal objects. Then, types of operation conflict are defined by operation events of two cooperative sides. Finally, the cooperative action between users based on SAT is analyzed and the mapping relationships between cooperative action and operation conflict type are established.

3.1 Definition of Operation Events

In G-CSCW, the object of one system is accomplished by a series of operation events. Users operate on the spatiotemporal objects and change their status (Claramunt and Thériault, 1996). The changes in status of spatiotemporal objects include 9 types: appearance, disappearance, stability, expansion, contraction, deformation, displacement, rotation and changes (fig.3-a). According to these types, operation events of users could be defined.



(a) The changes in status

- Add: user adds spatiotemporal objects. Its corresponding change status is appearance (fig.3-a-1).

- Delete: user delete spatiotemporal objects. The corresponding change status is disappearance (fig.3-a-2).

- Browse: user browse (zoom in, zoom out, pan) spatiotemporal objects. The corresponding status is stability because objects have no changes (fig.3-a-3).

– Modify: it means that people change the spatial attribute. The corresponding spatiotemporal object may expand (fig.3-a-4), contract (fig.3-a-5), deform (fig.3-a-6), displace (fig.3-a-7), rotate (fig.3-a-8), and the attributes also may change (fig.3-a-9). Fig.3-b is the mapping relationships.

No.	Change in status	Operations
1	Appearance	Add
2	Disappearance	Delete
3	Stability	Browse
4	Expansion	
5	Contraction	
6	Deformation	
7	Displacement	Modify
8	Rotation	
9	Changes	

(b) The mapping relationships

Figure 3. The mapping relationship between the changes in status of objects and the operation events

3.2 Classification of Operation Conflict

According to the types of the operation events of two collaborators, operation conflict can be classified into 10 kinds (fig.4): B2B, B2A, B2M, B2D, A2A, A2M, A2D, M2M, M2D and D2D.

– B2B (Browse and Browse): Both of two persons are browsing spatiotemporal objects. Their operations don't affect the status of objects. However, one user needs to inform the other user his current status because they have cooperative relationships. In fig.4-1, A and B represent two different users. The status of the objects in their views doesn't change because they perform Browse operations.

– B2A (Browse and Add): B is adding the objects (Add operation). A is browsing the data in the same area. A couldn't find real-time changes. Operation conflict occurs. In the fig.4-2, there is a new object 3 in the window of B. But the view of A doesn't change.

– B2M (Browse and Modify): B is modifying the objects (Modify operation). A is browsing the data in the same area. A couldn't find real-time changes. In the fig.4-3, Object 3 in the window of B has been modified. But the view of user A doesn't change.

– B2D (Browse and Delete): B is deleting the objects (Delete operation). A is browsing the data in the same area. A couldn't find real-time changes. In fig.4-4, object 3 in the window of B has been deleted (dashed). But the view of A doesn't change.

– A2A (Add and Add): Both A and B are adding objects. When A and B operate different object (fig.4-5-a), B can't find what A add in the real-time. When A and B operate the same object (fig.4-5-b), operations conflict because both A and B add object 2.

– A2M (Add and Modify): A is adding objects while B is modifying objects. If A and B operate different objects (fig.4-6-a), B can't find the object 2 that A add. If A and B operate the same object (fig.4-6-b), that is, A is adding the object 3 while B is modifying the object 3, conflict occur because one object couldn't be modified by two user at the same time.

– A2D (Add and Delete): A is adding objects while B is deleting objects. If A and B operate different objects (fig.4-7-a), B can't find the object 2 that A add. If A and B operate the same object (fig.4-7-b), that is, A is adding the object 3 while B is deleting the object 3, conflict occur.

– M2M (Modify and Modify): Both A and B are modifying spatiotemporal objects If A and B operate different objects (fig.4-8-a), A has modified object 2 but B can't find the real-time changes. If A and B operate the same object (fig.4-8-b), both A and B modify the object 2. Operations conflict.

– M2D (Modify and Delete): A is modifying the spatiotemporal objects. If A and B operate different objects (fig.4-9-a), B can't find the object 2 that A has modified, and A can't find the real-time change when B delete objects. If A and B operate the same object (fig.4-9-b), that is, A is modifying the object 2 while B is deleting the object 2, conflicts occur.

– D2D (Delete and Delete): Both A and B are deleting objects. When A and B operate different objects (fig.4-10-a), B can't find the changes that A cause and A can't find the changes that B cause. When A and B operate the same object (fig.4-10-b), both A and B are deleting object 3. Operations conflict.

3.3 Mapping between Operation Conflict and Cooperative Action

In the field of linguistic, Austin and Searle analyzed the types of speech and act among people. In the field of agent, Mario investigated the cooperative action among agents and the scope of activity and the direction of message to the corresponding cooperative action. Based on their researches, 5 kinds of cooperative actions among users in G-CSCW are defined in this paper.

– Inform: Inform is a unilateral and prescriptive cooperative action. It needs no answer. When people operate on the spatiotemporal objects, there is a need of notifying the other people to let them know about the states of the current user in real time.
– Update: Update is a bilateral and alternative cooperative action. It needs the answer from the opposite (approve or reject). When the states of the spatiotemporal object changes, there is a need of updating the view of the other user. for avoiding error decision. When the user receives a request for "Update", he can choose to approve or reject. As for the cooperative action of "Update", there are two kinds, namely, unilateral update and bilateral update. The former means that only one part has changed the states of related objects so only one user need to update the view of the other.

"Unilateral update" is abbreviated to "UU". Bilateral update means that both of the two sides have changed the states of some objects. So they both need to update the view of the opposite. "Bilateral update" is abbreviated to "BU".

- Reject / Approve: Both reject and approve are unilateral and prescriptive cooperative actions. Approve means that user agrees the request they receive while reject not. Usually, both of them are triggered automatically by other cooperative actions. "Reject" is noted as "R" and approve is noted as "A".
- Coordinate: Coordinate is a flexible action. When the cooperative users operate on the same spatiotemporal objects, they need to coordinate according to the roles of the users. And the operation results of user who have higher privilege role are reserved. Thereby, the system can get anticipant result. The coordinate mode between user A and user B can be described as rule 1. In this paper we called "Coordinate" as "C" for short.

Rule 1: $\forall$ RA, RB $\in$ R, OA, OB $\in$ O: RA $\leq$ RB $\Rightarrow$ OA $\leq$ OB, among which, $\leq$ represents one kind of partial sequence relationships, R represents the roles set and O represents operation set, R_A represents the role of user A and R_B represents the role of user B, O_A represents the operation of user A and O_B represents the operation of user B.

Different cooperative action is designed for dealing with different operation conflict. Table 1 is the mapping relationships between cooperative action and event conflict. In table 1, when one kind of operation conflict has two kinds of action, the upper means the methods used while people act on different objects and the lower means the methods used while people operate the same object.

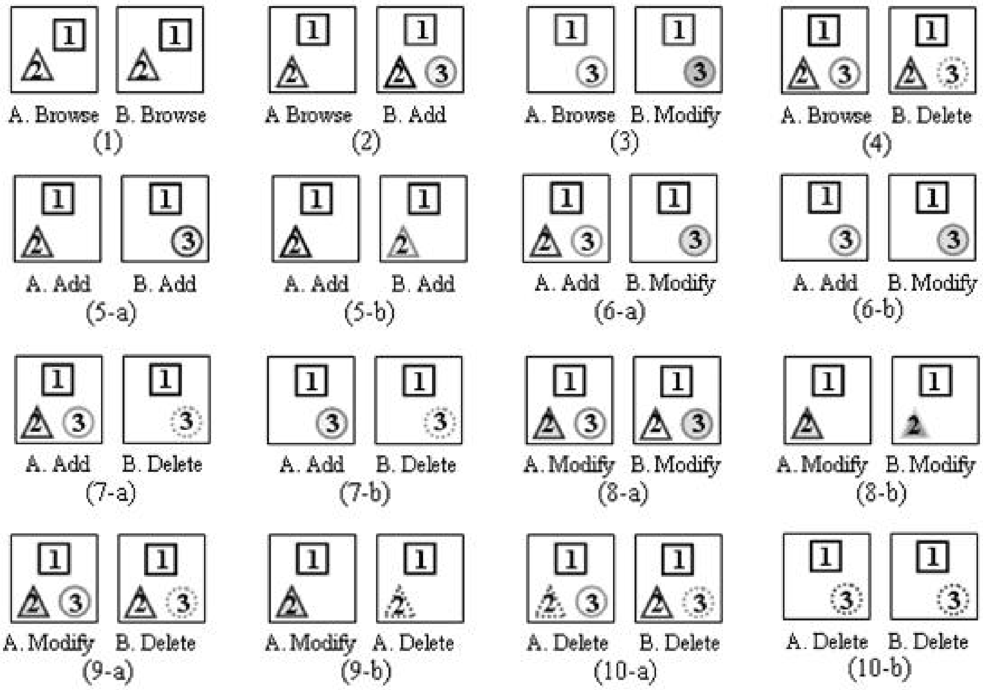


Figure 4. The types of operation conflict

Operations	Browse	Add	Modify	Delete
Browse	I	UU	UU	UU
Add	–	BU C	BU C	BU C
Modify	–	–	BU C	BU C
Delete	–	–	–	BU C

Table 1. Mapping between event conflict and cooperative actions

4. EXPERIMENT

In our work, we use Java language build a Browser/Server structure experiment system to test the SAT-based method presented in this paper. The experimental data includes the spatial data with scale 1:50000 stored in Oracle database. The related solution to operation conflict is implemented by several member functions of the class EventConflict. When one user operates the spatiotemporal object, the system searches the related users who have cooperative relationship with the current user. Then judge the type of operation conflict according to the type of operation event of the two collaborators. At last, applies the corresponding function in the class EventConflict to accomplish the coordination between people according to the mapping relationship. The process could be elaborated by fig. 5.

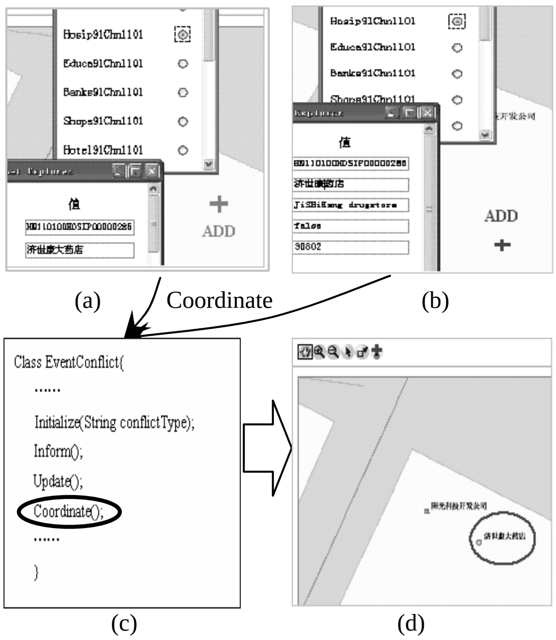


Figure 5. The process for handling operation conflict
(a) the operation of user A who has higher privilege, (b) the operation of user B who has lower privilege, (c) choose appropriate function in class EventConflict to handle operation conflict, (d) the operation results of user A are reserved

5. CONCLUSIONS

The paper presents a new idea for solving the operation conflict problem in GCSCW, that is, avoid conflict by the cooperation between people. It has the following characteristics. Firstly, it defines the operation events according to the changes in status of the spatiotemporal objects and defines the operation conflict according to the operation events of the collaborators. By this means, it considers the characteristics of the operation events. Secondly, the cooperative relationships among people are considered while dealing with operation conflict. It adapts more to collaborative applications.

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