

Q I QUÆSTIONES INFORMATICÆ

Volume 5 • Number 2

October 1987

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'n Amptelike tydskrif van die Rekenaarvereniging van Suid-Afrika en van die Suid-Afrikaanse Instituut van Rekenaarwetenskaplikes

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en van die Suid-Afrikaanse Instituut van Rekenaarwetenskaplikes

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*Computer Society of South Africa
Box 1714 Halfway House*

Quæstiones Informaticæ is prepared by the Computer Science Department of the University of the Witwatersrand and printed by Printed Matter, for the Computer Society of South Africa and the South African Institute of Computer Scientists.

A CAI MODEL OF SPACE AND TIME WITH SPECIAL REFERENCE TO FIELD BATTLES

E.C. Anderssen

S.H. von Solms

Computer Science Department,
RAU, Box 524, Johannesburg 2000

ABSTRACT

A computer aided instruction facility is presented, in which the simulation of field battles introduces history students to the dynamic relationships between space and time in a historical perspective. Information on a field battle is compiled by a history teacher or analyst, from textbooks or other historical material. The facility provides for the transformation of information obtained in this way into computer database relations. The progress of a field battle is simulated when a student interactively requests a graphical display of events.

1. INTRODUCTION

Until recently the majority of CAI programs available for the teaching of history only provided elementary facilities [2]. There is however, a tendency towards the application of more sophisticated AI techniques in the development of simulation models for history teaching [3]. A wide variety of simulation models can be developed for a subject such as history. Wargame simulation models have been in use for many years. These simulation models range from real world military planning models to gameroom models where the make believe general wages a war using lead soldiers [6]. Wargame models can also be used in the history classroom [7] [8]. The model described in this article is directed towards the needs of history students. The model highlights certain concepts in relating space and time in a historical perspective. These concepts are conveyed to the student through the simulation of field battles on a micro-computer.

2. THE SPACE-TIME CAI MODEL

The CAI facility is applied in *three* steps to construct the space-time model. In the *first* step, a competent history teacher or analyst extracts relevant information on a field battle from a history textbook and translates these facts into input notation for the scenario of a field battle (figure 1). In the *second* step the scenario is entered into a computer and loaded into the system's database (figure 2). In the *third* step a student interactively formulates his queries on space and time aspects of field battles and interprets the answers displayed in the form of text and graphical images on the computer's screen (figure 3).

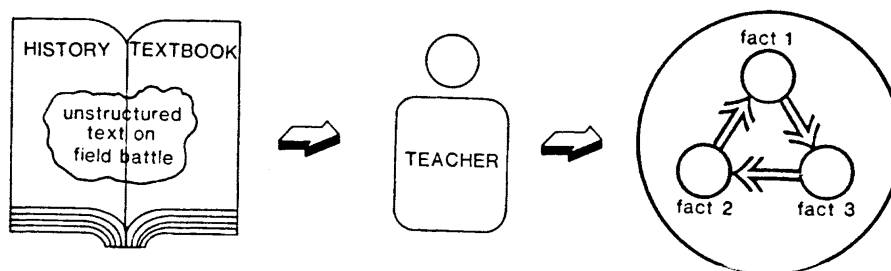


figure 1

A Teacher Analyses a Field Battle and Translates the
Information into the Input Notation for the Scenario.

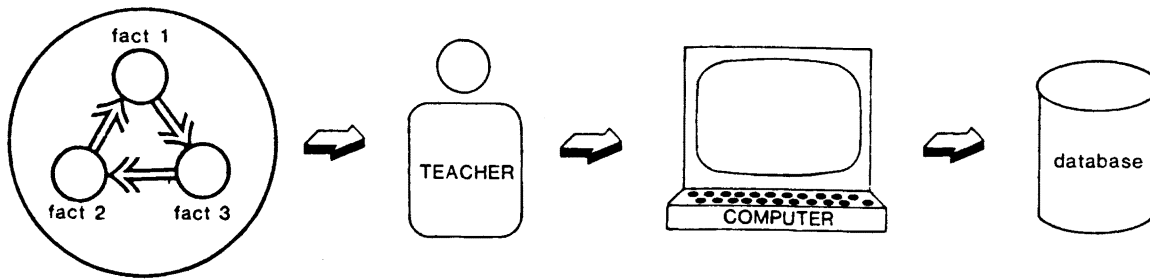


figure 2

The Scenario of a Field Battle is Loaded into the System's Database.

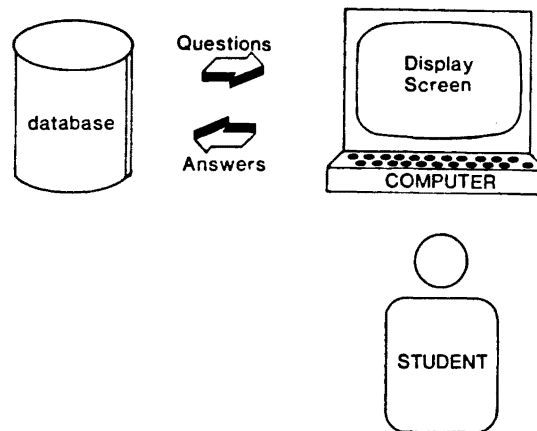


figure 3

The Student Formulates Questions and Receives Answers in the Form of Text and Graphical Images.

For the purpose of the space-time model, the scenario of a field battle is structured into three basic components, the meaning of which is discussed in the following paragraph.

3. THE STRUCTURE OF THE SCENARIO OF A FIELD BATTLE

A field battle is a complex phenomenon with many interrelated components. One could therefore expect that a field battle can be simulated in a variety of ways. For the purposes of the model discussed here, the scenario of a field battle is structured into the following three components:

- (1) The Geographical terrain component (rivers, roads etc.);
- (2) The Movable object component (weapons, vehicles etc.);
- (3) The Event component (human actions and activities).

The structure and function of the three components are discussed in the following paragraphs.

3.1 The Geographical Terrain Component

The analyst consults a history textbook to obtain a geographical map of the scene of a field battle. The entities on the map such as roads, contour lines etc, are individually encoded into the input notation. These specifications collectively form the geographical terrain component of the scenario of a field battle. The specifications are filed in the geographical database of a micro-computer. When a display of the map of the field battle is requested, the database relations are interpreted as graphical images on the screen of a computer.

A geographical terrain specification consists of the following fields:

G#9999 Id(...) RepMode(...) GeoType(...) Co(...)

The meaning of the fields are explained with reference to the following fictitious example (see figure 4):

G#110 Id(Fish River) RepMode(line) GeoType(river) Co(x₁y₁,x₂y₂,...)

- The field *G#110* is a compulsory number, used to identify a geographical terrain specification uniquely.
- The *Id* field assigns a *name* to an entity, with which it is identified on the map displayed on the screen.
- The *RepMode* field determines the way in which an entity is displayed on the geographical map. Usually three display modes are used for this purpose [5]. The modes are *area* mode, where an entity, for example a dam, is represented as a closed polygon and painted with some characteristic symbol; *line* mode, where an entity is represented as an open line figure, for example a contour line, and *point* mode, where an entity is represented as a dot. In a fourth mode, an entity is represented as an *icon*, using some characteristic sprite figure.
- The *GeoType* field specifies the geographical type of an entity, for example a river, bush, church etc.
- The *Co* field specifies the cartesian coordinates of an entity. The number of coordinate pairs used for the representation depends on the representation mode selected for the display. For example a line or area is represented by a set of coordinates, whereas the position of an icon or point is determined by only *one* coordinate pair.

Let us consider the following more extended example, where a map of the scene of an imaginary field battle is converted into input notation. The map is given below (figure 4).

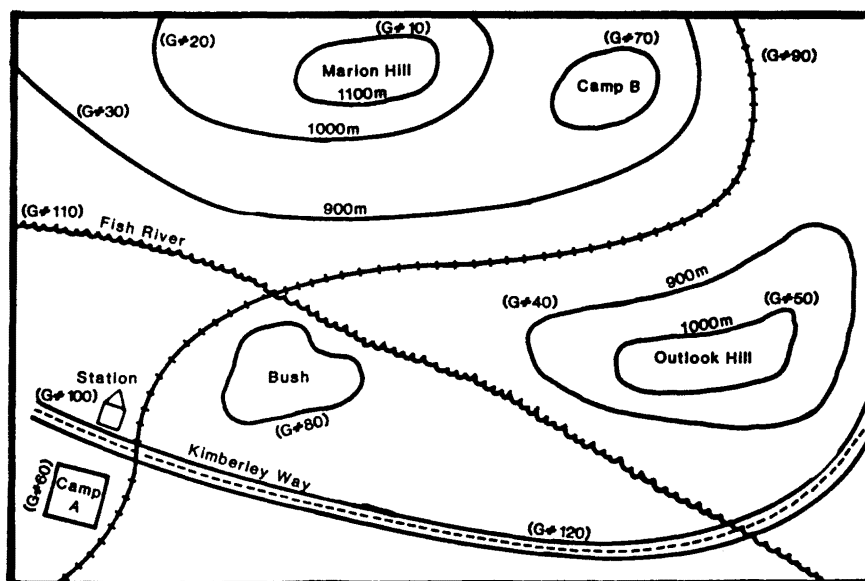


figure 4

The Map of the Scene of the Imaginary Field Battle.

According to the scheme mentioned above, the geographical terrain specifications of the map are:

G#10	Id(1100m; Marion Hill)	RepMode(line)	GeoType(contour)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#20	Id(1000m)	RepMode(line)	GeoType(contour)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#30	Id(900m)	RepMode(line)	GeoType(contour)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#40	Id(900m)	RepMode(line)	GeoType(contour)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#50	Id(1000m; Outlook Hill)	RepMode(line)	GeoType(contour)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#60	Id(CampA)	RepMode(area)	GeoType(camp)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#70	Id(CampB)	RepMode(area)	GeoType(camp)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#80		RepMode(area)	GeoType(bush)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#90		RepMode(line)	GeoType(railway line)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#100		RepMode(icon)	GeoType(railway station)	Co(x ₁ y ₁)
G#110	Id(Fish River)	RepMode(line)	GeoType(river)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)
G#120	Id(Kimberley Way)	RepMode(line)	GeoType(main road)	Co(x ₁ y ₁ ,x ₂ y ₂ ,...)

Where sophisticated digitising equipment is not available, the input of coordinate pairs can be cumbersome. It is therefore preferable to reduce the number of coordinate pairs for the description of geographical entities, by the application of B-spline interpolation techniques [4]. According to this approach, new coordinate points are interpolated between existing ones. By interconnecting these interpolated points, a fairly smooth curve can be obtained. The addition of two interpolated points between every pair of input values result in a stable and adequate curve.

3.2 The Movable Object Component

A certain class of objects can be moved about from one location to another. For example, a vehicle can be used for transport; troops can march from one place to another or a cannon can be placed at a strategic position.

The description of a movable object is encoded in the following input notation:

M#9999 Id(...) Type(...) Number(...) Part_of(...)

The specification of movable objects is illustrated by way of the following example, taken from the narrative describing the imaginary field battle: "The Scout Group, a cavalry unit of 25 men, forms part of the Central Commando."

The input notation for the example is:

M#10 Id(Scout Group) Type(Cavalry) Number(25) Part_of(Central Commando)

- The first two fields have the same meaning and function as the equivalent fields in the geographical terrain specification.
- The *Type field* determines the characteristic figure or icon used for representing the object on the map displayed on the screen. For example a cavalry unit can be represented by a crossed rectangle.
- The *Number field* indicates the number of individuals comprising the movable object.
- The *Part of field* defines the relationship between the movable object and another movable object. In the example the Scout Group forms a subsection of the Central Commando.

3.3 The Event Component

In general terms an event can be defined as anything that happened in a space-time context. An event is based on the concept of a time interval [1], and therefore has a start time, an end time and a duration. An event specification is the notation for an action which took place during a field battle.

An event specification consists of the following fields:

E#9999

- (i) *Date and time specification:* dA(...) dB(...) tA(...) tB(...) dt(...)
- (ii) *Action specification:* action(description(...) instrument(...) speed(...) route(...))
- (iii) *Subject specification:* subject(id(...) locality(...) number(...) placement(...))
- (iv) *Direct object specification:* direct_obj(id(...) locality(...) number(...) placement(...))
- (v) *Indirect object specification:* indirect_obj(id(...) locality(...) number(...) placement(...))

The meaning of the different fields can best be explained with reference to an example. Let us assume the following narrative is an excerpt from a description of the field battle which took place at the scene of the map given in figure 4:

“The troops left the camp between the road and the railway line, south west of the station at sunrise on the 18th of February. They followed a route parallel to the railway line, and reached the bush just south of the railway crossing over the river at lunch time. After a rest period of two hours, they departed and reached the camp area on the plateau just north of the railway line and immediately west of Marion Hill, without any mishaps, at sunset.”

In this example references to space and time are vague. The model provides two options for the translation of the references into event specifications. One option is for the analyst to use his own judgement in translating these vague references into more precise terms. The time references can be translated by assuming that sunrise was at 5.30 a.m. (05h30); lunch time was at 1 p.m. (13h00) and sunset was at 6.30 p.m. (18h30). The space references have to be rewritten in terms of cartesian coordinates. These coordinates can be obtained from the geographical map of the terrain of the field battle. Let us assume that the following coordinates were traced:

- Camp between road and railway line: $x_i y_i$
- Route parallel to railway line: $x_j y_j, x_k y_k, \dots x_l y_l$
- Bush south of the railway crossing: $x_m y_m$
- Route from bush to camp on the plateau: $x_p y_p, x_q y_q, \dots x_r y_r$
- Camp area on the plateau: $x_s y_s$

The incorporation of these norms results in the following event specifications:

E#10 dA(2/18) tA(05h30) tB(13h00)
 action(description(move) route($x_j y_j, x_k y_k, \dots x_l y_l$)) subject(id(troops)
 locality(locA($x_i y_i$), locB($x_m y_m$))

E#20 dA(2/18) tA(E#10.tB) dt(2 hours)
 action(description(rest and eat)) subject(id(troops)
 locality(locA(E#10.locB))

E#30 dA(2/18) tA(E#20.tB) tB(18h30)
 action(description(move) route($x_p y_p, x_q y_q, \dots x_r y_r$)) subject(id(troops)
 locality(locA(E#20.locA), locB($x_s y_s$))

The following explanation will clarify the meaning of these fields:

Event E#10
 dA(2/18) : Commencing date, the second month, the 18th day;
 tA(05h30) : Commencing time, 5.30 a.m.;
 tB(13h00) : Completion time, 1 p.m.;
 route() : The coordinates of the route;
 locality(locA() , locB()) : The initial and final localities of the troops.

Event E#20
 tA(E#10.tB) : The commencing time of this event coincides with the completion time of event E#10.
 dt(2 hours) : The duration of the event is 2 hours.
 locality(locA(E#10.locB)) : The initial location of the troops is the same as their final location in event E#10.

Apart from such precise input, the system accepts vague event specifications for translation into more specific space and time values according to prestored information, for instance “sunrise is at 5.30 a.m.”. The following event specifications serve as input:

```

E#10  dA(2/18) tA(sunrise) tB(lunch time)
       action(description(move) route(parallel railway_line)) subject(id(troops)
       locality(locA(camp(loc(between road railway line, SW station))),
       locB(bush(loc(S,near railway_crossing(loc(over river)))))))
E#20  dA(2/18) tA(E#10.tB) dt(about 2 hours)
       action(description(rest and eat)) subject(id(troops) locality(locA(E#10.locB))
E#30  dA(2/18) tA(E#20.tB) tB(sunset)
       action(description(move) route(locA, locB)) subject(id(troops)
       locality(locA(E#20.locA),
       locB(camp(loc(plateau(loc(N railway_line), (W Marion Hill)))))))

```

4. LOGICAL DATA STRUCTURES AND DATABASE RELATIONS

The preceding paragraph indicated how the teacher or analyst can go about analysing a field battle and how input specifications for the representation of a field battle can be formed. These representations are stored as physical data structures in a micro-computer’s database. The logical counterpart of these physical data structures plays an important part in the formulation of questions on a field battle. The layout of the logical data structures is presented as *database relations*. Before the structure of some of the database relations is discussed, the overall data structure is shown in the following diagram (figure 5).

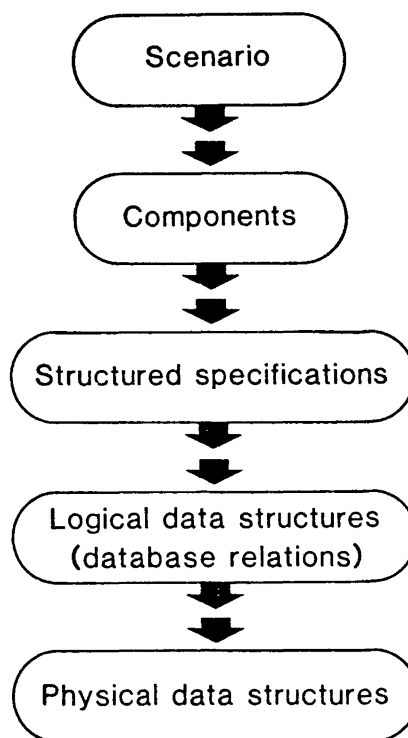


figure 5

Relationships between Structural Concepts on Different levels.

Double arrows indicate one-to-many relationships.

We now turn to the formation of database relations. The relations needed for the logical description of the database are divided into two groups. Firstly we have the *main relations* which determine the relationships between the logical data structures. Secondly *index relations* are used to build indexes on a selected number of fields of certain relations in order to facilitate queries on different aspects of a field battle.

4.1 Main Relations

The system provides for a number of database relations, of which only two are presented here:

Main Relation 1: Geographic terrain relation

This relation ties together the geographical terrain specification number (G#), the identification of the entity (geo_Ident) and the type (geo_Type) of the entity, such as a contour line, a bridge, a river etc. The relationship has the following layout:

Geographic (G#, geo_Ident, geo_Type)

Main Relation 2: Coordinate relation

The *Coordinate relation* identifies the (X,Y) cartesian coordinates of a geographical terrain entity on the map of the scene of a field battle. It has to be noted that an entry exists for every (X,Y) coordinate pair belonging to a specific geographical entity. The coordinate relation has the following layout:

Co (G#, X, Y)

4.2 Index Relations

For the purposes of our discussion, only three of the defined index relations are given below:

Index relation 1: Commencing date-time, event number index relation

This index relation gives the commencing date and time of every event:
Commencing_DT_EventNumber (*commn date, commn time, event_number*)

Index relation 2: Completion date-time, event number index relation

As the name implies, the completion date and time of every event is given by this relation: Compl.-DT_EventNumber (*compl date, compl time, event_number*)

Index relation 3: Name, event number index relation

This index relation unlocks all the events in which a specific person or group of persons participated. The two fields of the relation are the *name* of the person and the number (*E#*) of the event in which the person was involved: Name_EventNumber (*name, E#*)

5. THE APPLICATION OF THE MODEL

After the specification of a field battle has been completed, a student can formulate his questions on relevant space and time aspects of the field battle. He uses an interactive menu with which the following selections can be made:

- *Selection of the subject/object*

Using this menu option, the student selects the names of the persons he wishes to include in the display sequence. The system locates the events in which these names appear in the database by using the *Name,event number index relation* (Index relation 3).

- *Selection of the time span*

The student chooses the time span of the events to be included in the display sequence by specifying the desired commencing and completion times, using the *Commencing date-time and Completion date-time* index relations (Index relations numbers 1 and 2).

- *Selection of the geographical terrain entities*

If all the geographical entities appearing on the map were to be selected for display, it could lead to an overcrowded screen, making the interpretation of the figures

rather difficult. In order to overcome this problem, the student has the option of selecting the geographical types of the various entities he wishes to display. For example, all the contours and rivers can be selected. The selected entities are located by using the *Geographic terrain relation* (Main relation 1). The coordinates of the selected entities are obtained from the *Coordinate relation* (Main relation 2).

- *Selection of a section of the geographical terrain*

The student can interactively select a specific section of the geographical terrain by defining a window on the screen. The zoom function can be used for changing the scale of the window area.

- *Selection of the display mode*

The student has a choice between two display modes. In the first place the continuous progression mode can be used. In this mode, the student specifies the time scale between simulated time and actual real time. For example it can be specified that one minute simulated time is equivalent to one hour of actual real time. Under continuous mode, the progression of the field battle cannot be interrupted. The goal of this mode is to bring the relative duration of events to the attention of the student.

In the *second place* the progression of simulated time can be controlled by the student. Before starting the simulation, the time unit to be used for incrementing simulated time is specified. For example, if the time increment is set to a value of one hour, the progression of the field battle is displayed in steps of one hour intervals with each display request. This display mode enables a student to advance through the events at his own pace.

- *Selection of the snapshot facility*

When this facility is used, a snapshot of all the items on the display screen at that moment in simulated time, is taken. This image of the scenario is labelled with an unique number, time stamped, and stored away in the database. The snapshot can be recalled and displayed on the screen when needed.

6. IMPLEMENTATION OF THE MODEL

Further research on the representation of historical space and time relationships is still in progress. It is envisaged to implement the system on a micro-computer and to assess its acceptance by students in a practical classroom situation. The set of programs needed for the display of the geographical map of a field battle, has been implemented, using *Turbo Pascal*. The digital representation of the map of the imaginary field battle (figure 4) was used as input to this set of programs. The map produced by the system is shown in figure 6.

7. ENHANCEMENTS TO THE MODEL

The event structure of the model opens the possibility of loading the account of different observers on a specific historical situation into the database. The accuracy of the description of an event often depends on the alertness of the observer. It can be expected that many of an observer's references to space and time will be of a vague nature. For example, if it was mentioned in the account that some event took place "near" some location, deductions on the exact locality of the event have to be made by the system. The separate accounts can be compared by the student in order to determine their credibility.

8. CONCLUSION

A space-time model for the representation of historical events was developed. The model uses a database containing geographical and event specifications of a field battle. It is envisaged that a student will be able to ask interactive questions on a military field battle, using the information in the database. The system responds to questions by giving a geographical display of the field battle on the CRT screen of a computer. It is foreseen that the system could be

extended to make provision for the comparison of often vague accounts of different observers on the same historical situation.

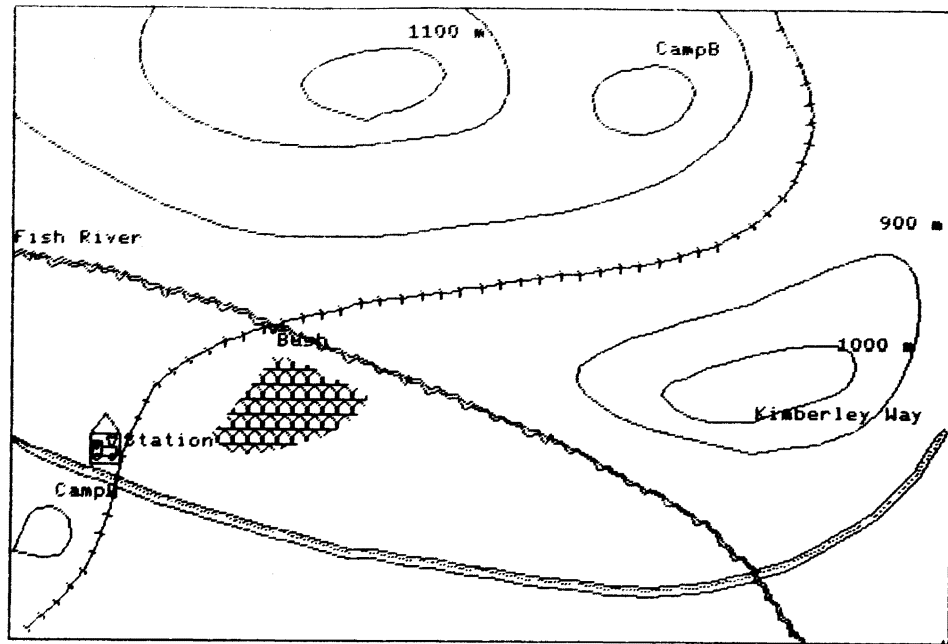


figure 6

Computer Generated Map of the Imaginary Field Battle.

ACKNOWLEDGMENT

We would like to thank Chris Myburgh from the Faculty of Education at the RAU for his helpful comments.

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