Embedding virtual reality visualisations and mobile technologies as integrated components of the curriculum: Experiences within Geographical Information Science

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SPLINT
SPatial Literacy IN Teaching

Introduction

This research sits within the framework of pedagogic strategies promoting spatial literacy in the teaching of GIScience. We argue that the development of spatial literacy is important both to support students from a variety of disciplines taking courses in geographical information systems but with little geographical background, and to assist in the transfer of GIScience approaches to other disciplines less associated with geographical concepts. Anecdotal evidence and phenomenological research has established that a number of students have particular difficulty in “seeing” spatial representation within mathematical or algorithmic notation. Taking a unit visualising locational errors relating to global positioning systems (GPS) as an example, we report the integration of traditional lecture material, an immersive virtual reality session and practicals involving the outworking of learning concepts using handheld mobile devices.

Educational Impact

There is a need to know what particular impact immersion and 3D graphics have on learning processes; the approach is after all resource intensive. We know that learning accumulates; whether a particular visualisation “works” is a function (among other things) of prior knowledge and the alignment of the external visualisation with the internal representations (or learning goals) we wish the students to achieve. Of particular interest are whether the spatial contingency between immersive visualisation and initial practical work is a significant factor when generalising models for blended processes in geography; whether the repetition of themes across a range of external representations and active or passive environments contributes to a cumulative learning experience; or whether the approach appears to motivate and encourage autonomous thinking by including different representations that appeal to a variety of student learning styles.

Unit 1: Traditional lecture

Students are given a short (10 minutes for undergraduates, 20 minutes for postgraduates) lecture.

- Lecture material covers; the basic principles of GPS, the limitations of GPS and measures of GPS locational quality.
- Mathematical explanation of satellite strength (PDOP) introduced

$$\hat{x} = \left(A^T A\right)^{-1} A^T b \qquad \text{PDOP} = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2}$$

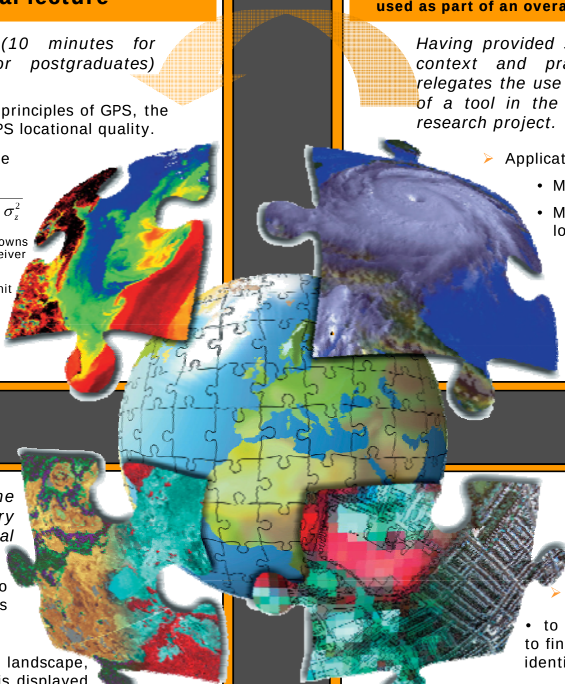
Where:

$\hat{x}$ corrections to priori estimates of the four unknowns (i.e. the receiver position (x, y, z) and the receiver clock bias τ)

A the design matrix containing the line of sight unit vectors & 1s.

b the difference between the measured pseudoranges & calculated ones.

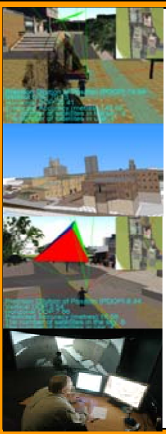
DOP values Function of the diagonal elements of the covariance matrix



Unit 4: Research skills: GPS-enabled mobile devices used as part of an overall environmental research exercise

Having provided students with an initial theoretical context and practical skills training, this unit relegates the use of GPS-enabled mobile GIS to that of a tool in the service of a wider environmental research project.

- Applications include:
  - Mapping different vegetation types.
  - Measuring environmental variables and locating sensors.
- Technical assistance is reduced both in terms of focus and staff skill set, although help and encouragement in the use of GPS and mobile GIS does also form part of this one day field unit.



The students watch as a real-time simulation of GPS satellite geometry is carried out in the virtual environment.

- The number of satellites visible to the receiver is modelled in real time as a user walks through the campus.
- As the user walks through the landscape, Position Dilution of Precision (PDOP) is displayed on the screen while the satellite geometry is visualised in both 3D and via an aerial view.
- The tour, and discussion, is led by a member of staff who is able to guide the students to particularly significant locations in this environment regarding GPS satellite accuracy.

Unit 2: 3D stereo VR: Visualisation of GPS satellite visibility & its effect on PDOP

Students undertake a practical exercise designed to build their mobile GIS skills using Arc PadTM.

- The goals of this practical are:
  - to use the GPS facility within ArcPadTM to find their way to pre-selected points and identify what lies at those locations.
  - to collate detailed data of geographical features not marked on standard Ordnance Survey 1:10,000 mapping, such as statues and flower borders.
- In the case of MSc students, comparisons between single receiver and differential corrected GPS signal data are made for these points of interest in the laboratory as a more advanced second element to the practical work.

Unit 3: Skills building practical: Using GPS-enabled mobile GIS for point/polygon data capture

Case Study: Positional errors from GPS receivers

The case study we present is designed to facilitate understanding of locational errors relating to global positioning systems (GPS); complex space-time phenomena of both intellectual and practical significance within the curriculum. In the context of GIS teaching about location-based services, knowledge of these issues is intellectually important. Practically too, as we introduce mobile GIS to the curriculum, students need to become familiar handling GPS in the field and require a level of awareness that will allow them to assess the fitness for use of the locational data that they collect in association with other environmental data.

Four units are used to build students’ awareness of GPS and mobile GIS, in a variety of configurations

Key Findings & Discussion

Initial findings suggest that the direct spatial connection between the VR visualisation of GPS accuracy and the subsequent mobile computing practical across campus provides a powerful means of altering behaviour.

- Participant observation of student awareness of GPS accuracy in the research-focused field day suggests that in the main students were able to evaluate the causes of signal loss (e.g. within trees), tying GPS accuracy and sample strategy together well.
- Strong evaluative scores were received regarding the degree to which students felt they could evaluate the fitness for use of mobile digital equipment versus traditional pen and ink approaches, suggesting that learner autonomy was promoted.
- The majority of our learners considered themselves to learn particularly well using visual materials and practical activities; all were in favour of the *combined* approach, suggesting that the blend we applied promoted engagement.
- When asked what they enjoyed most about a GIS module, student A said he liked “*seeing an actual application of something we'd learnt about first and then see it visually*”.

Initial student evaluations of the mission tool and its role in the teaching about GPS accuracy have raised a number of issues for further investigation.

- Blending visual and active learning for the *same geographical space* is a process that appears to have advantages. However, what we do not know is whether the effect would be equally strong if GPS accuracy was presented for an alternative urban environment, and how the knowledge about GPS accuracies learned on campus is subsequently extrapolated to alternative field sites in detail.
- Whether the VR approach is *necessary* as an instructional method is a different question, the answer to which is likely to vary according to the ability of individual students to imagine spatial manifestations of mathematically described events.
- The use of a blend of materials not only contextualises the use of VR but also suggests that variation is actually of critical importance if its visual potential for enhancing spatial literacy is to be maximised. Over several additional student cohorts we hope to explore these ideas further and ground them on a wider evidence base.