Omega Special Issue: Ethics and Operational Research

Ethical issues in tracking cellular telephones at an event

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Abstract

Early in 2007, the CSIR conducted an experiment to track the cellular telephones of a small group of people as they moved to and from an event, to test the viability of using such tracking to provide the participants with useful traffic information. This project raised a number of ethical issues, which prompted this paper and which we discuss here. These include:

- The ethics of modelling data, including the treatment of research participants;
- Privacy and surveillance issues related to tracking the movement of people;
- The risks inherent in being tracked *vs* the benefits of being tracked; and
- The ethics related to sending messages to drivers.

We have reviewed the literature on ethics and used the results to assemble a check list of relevant ethical issues, adding a few of our own (ie a deontological ethics approach), against which the conduct of this research project was assessed. We also provide an overview of the experiment and the results obtained.

Key words: Case study, Location, Routing, Cellular Telephone, Tracking; Ethics

Cooper AK, Ittmann HW, Stylianides T & Schmitz PMU, December 2009. *Ethical issues in tracking cellular telephones at an event*. Omega, 37(6), pp 1063-1072.
DOI: 10.1016/j.omega.2008.10.002
https://www.sciencedirect.com/science/article/pii/S0305048308001424

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1. Introduction

Early in 2007, the CSIR conducted an experiment to track the cellular telephones (cell phones) of a small group of people as they moved to and from an event, to test the viability of using such tracking to provide the participants with useful traffic information. This project raised a number of ethical issues, which prompted this paper. We have conducted a survey of the relevant literature on the ethics of modelling and of surveillance. From these, we have assembled several tables that could be used as 'check lists' for assessing the ethics of an operational research project in general, and of a surveillance project in particular. We then describe our project and assess it against these check lists. Of course, check lists are not necessarily required for a project to be executed ethically and they alone cannot guarantee that a project will be executed ethically, but they can give one peace of mind that one is probably doing the correct thing. We hope that this paper contributes towards an understanding of good practice in operational research.

2. Brief survey of the relevant literature

2.1 Ethics of modelling – a review

"The use of mathematical models to support decision making is proliferating in both the public and private sectors. Advances in computer technology and greater opportunities to learn the appropriate techniques are extending modelling capabilities to more and more people.

As powerful decision aids, models can be either beneficial or harmful. At present, few safeguards exist to prevent model builders or users from deliberately, carelessly, or recklessly manipulating data to further their own ends. Perhaps more important, few people understand or appreciate that harm can be caused when builders or users fail to recognise the values and assumptions on which a model is based, or fail to take into account all the groups who would be affected by a model's results" [1].

The above was the driving force behind a workshop on "Ethics in Modelling" held in 1989. Much of what was behind this workshop still holds today. In fact, the situation is possibly more complex today, especially with the almost exponential growth in computer technology and in the availability of sophisticated software. Today, much more so than in the past, people, and especially non-experts, have access to this technology, giving them the ability to build models and to make them increasingly complex.

Ethics, from the Greek word ἤθος (*ēthos*) meaning custom or habit, is a branch of philosophy concerned with the nature of ultimate value and the standards by which human actions can be judged right or wrong. The term is also applied to any system or theory of moral values or principles. Ethics is traditionally subdivided into *normative ethics*, *metaethics* and *applied ethics*. Normative ethics seeks to establish norms or standards of conduct (the study of how to determine ethical values). Metaethics is concerned with the nature of ethical judgments and theories (the study of the concept of ethics). Applied ethics consists of the application of normative ethical theories to practical moral problems (the study of the use of ethical values) [2].

Metaethics falls outside the scope of this article because we are not developing any new theory of ethics. Similarly, although the entire exercise is one of applied ethics, an attempt to apply ethics theory to a real-life situation, the focus in this review is on normative ethics.

There are three major approaches in normative ethics, *virtue ethics*, *deontological ethics* and *consequentialism*. Virtue ethics emphasises virtues or moral character; Aristotle is a pioneer virtue ethicist. Deontological ethics emphasises duties or rules; Immanuel Kant set out a framework for a deontological normative ethical theory. Consequentialism emphasises the consequences of actions; John Stuart Mill set out a framework for classical utilitarian normative ethics, the simplest form of consequentialism. Suppose it is obvious that someone in need should be helped. A consequentialist will point to the fact that the consequences of doing so will maximise well-being, a deontologist to the fact that, in doing so the agent will be acting in accordance with a moral rule such as "Do unto others as you would be done by" and a virtue ethicist to the fact that helping the person would be charitable or benevolent [3].

In referring to Slote [4], Walker [5] states that unethical behaviour means consciously doing something you know, or society says, should not be done and that these behaviours include deception, bias, lying, falsification, distortion and withholding information. Many of the issues that are being addressed when modellers talk about ethics are not necessarily ethical questions but rather questions concerning good practice. By following good practice one attempts to minimise unethical behaviour or promotes ethical behaviour.

The growth in the availability of quantitative data, the use thereof, and the complexity and significance of models raises many ethical questions such as [6]:

- What is the proper relationship between the model builder and the model user?
- Should model builders assume professional responsibility for the results of their model?
- Do model builders have a responsibility to those affected by the results of their models besides their clients?

Walker [7] discusses the role of the modeller vis-à-vis the decision maker and describes the tenets of “good practice” in model building. He does this in the context of the policy analyst but what is outlined is as applicable to modellers. This is done according to the stages in the process of building models. For each stage the responsible and prudent behaviour that should be expected from the modeller is described. Gass [8] gives his views on “ethical concerns and ethical answers” and feels quite strongly that a code of ethics is required for modellers. He does state, however, that through experience he “just knew what was right and what was wrong” specifically when it concerned ethics. Gass [9] describes efforts by OR societies to establish such guidelines and notes that there is a reluctance to the adoption of such guidelines. In analysing rational-style model-based policy analysis, Walker [5] takes this further, arguing that following the tenets of good practice is necessary, and generally sufficient, to ensure ethical conduct.

There is very little literature on ethics in modelling or, for that matter, on ethics in Operational Research/Management Science (OR/MS). Interest has grown over the last ten years and a few papers have been published on this topic (for example Brans [10], Brans [11], Gallo [12] and Brans & Gallo [13]), while a Working Group on Ethics was established within EURO (the European Operational Research fraternity). Gallo [12] proposes two ethical principles that can assist Operational Researchers and practitioners, namely the *responsibility principle* and the *sharing and cooperation principle*. The first principle calls for the Operational Researcher to take into account not only the point of view of the client but in fact that of all stakeholders – ie all those affected, directly or indirectly, by the results of their activities. Müller-Merbach [14] is explicit in considering *ethical action* to be part of the responsibility principle for Operational Researchers. The second principle, in turn, calls for a more open distribution of research results and activities.

2.2. Ethical transgressions in research

There have been many attempts throughout the world to define research misconduct and associated ethical transgressions which led to much controversy. As the White Paper on Promoting Integrity in Scientific Journal Publications of the Council of Science Editors (CSE), Reston, VA, USA puts it:

"*Unfortunately, a single definition of scientific misconduct does not exist in the scientific community, although most definitions include falsification, fabrication, and plagiarism. This multiplicity of definitions can be explained in part by the multiple national bodies within a country that may be attempting to address the problem. Further, in most countries that have developed a formal response, universities and research institutions are encouraged to develop their own definitions and responses, provided the definitions and processes contain elements mandated by national regulations. Finally, the definitions of misconduct are influenced by the legal structure of the countries in which they exist, the nature of the national body that has assumed the greatest responsibility for responding to the problem, and the ethical norms of the scientific community.*" [15].

It is not the purpose of this article to list or compare the various definitions of ethical violations. Instead, for the purpose of considering the ethical issues encountered in the project (described below), we shall provide certain widely accepted definitions of relevant terms.

Fraud is a deliberate misrepresentation or perversion of the truth in order to obtain an unjust advantage or to injure the rights or interests of another person. The resultant prejudice, actual or potential, need not only be financial or proprietary although these are probably the most common forms of fraud.

The difference between fraud and an honest *error* is a matter of intention. Fraud is deliberate whereas an error is accidental.

Research misconduct involves "*fabrication, falsification, plagiarism or other practices that seriously deviate from those that are commonly accepted within the scientific community for proposing, conducting or reporting research. It does not include honest error or honest differences in interpretations or judgments of data*" [USA Public Health Service, Policies and Procedures for Dealing with Possible Misconduct in Extramural Research, as quoted in 16].

Unlike fraud, misconduct may not necessarily involve the harm of the rights or interests of another person but only deviation from accepted practices. Furthermore, the term is often used in a narrow sense and does not include all transgressions of norms and standards of research ethics. In particular, it may not include issues relevant to the rights and protection of research participants, be them humans or animals. Ethical notions relevant to the treatment of research participants are discussed later in this article (see section 2.4).

Another definition, offered by the Commission on Research Integrity appointed by the US Department of Health and Human Services (HHS), provides general criteria for research misconduct instead of listing specific violations. It includes the following statement: "*Research misconduct is significant misbehavior that fails to respect the intellectual contributions or property of others, that intentionally impedes the progress of research, or that risks corrupting the scientific record or compromising the integrity of scientific practices...*" [17].

The term "scientific misconduct" is often used as a synonym for "research misconduct," although science is much more encompassing than just research.

The terms *research fraud* and *scientific fraud* are also used by some, and used interchangeably, to describe an intentional misrepresentation of scientific results which does not necessarily lead to financial gain. Instead, this misrepresentation is a type of professional misconduct (in many cases it is considered to coincide with misconduct with the term fraud being used to accentuate the violation) and satisfies only some of the criteria pertaining to fraud proper, for example, there may not be a plaintiff who suffered damage as a result of such an action [17].

Despite the significant differences between error, misconduct and fraud, the consequences for research and science of all three acts are similar. Someone could be led to doubt something that is true or to believe something that is false. Therefore, it makes little difference to the progress of science whether the error was intentional or not [16].

2.3. Ethics of modelling - Best-practices

There are very few formal codes of professional ethics for mathematical scientists or even scientists in general. In 1971 ORSA (the American OR society) drafted some guidelines for their members [18] which can be considered very basic and require updating, as suggested by Machol [19]. Deming also drafted a “code of professional conduct” [20], while more recently “the Oath of Prometheus” was published [11]. The emphasis in the latter oath is on the practice of operational research to ensure “sustainable development” for future generations. In his recent review, Gass [9] highlights the paucity of codes of ethics adopted by OR societies, though he feels such codes are necessary for professional societies. As implied in Section 2.1, ethics has been “hidden” in the good practices used by scientists and ethical issues are often perceived as technical issues and dealt with as such. Hence, scientists following the good practices of their disciplines have generally been adhering to ethical practices, without necessarily considering that they were doing so explicitly.

Ören et al [21] have developed a Code of Professional Ethics for Simulationists which is divided into the following five sections:

- Personal Development and the Profession
- Professional Competence
- Trustworthiness
- Property Rights and Due Credit
- Compliance with the Code.

The stipulations of the section on Professional Competence of this Code are given in Table 1.

Table 1: Professional Competence – Code of Professional Ethics for Simulationists (extracted from [21])

1.	Assure product and/or service quality by the use of proper methodologies and technologies.
2.	Seek, utilize, and provide critical professional review.
3.	Recommend and stipulate proper and achievable goals for any project.
4.	Document simulation studies and/or systems comprehensibly and accurately to authorized parties.
5.	Provide full disclosure of system design assumptions and known limitations and problems to authorized parties.
6.	Be explicit and unequivocal about the conditions of applicability of specific models and associated simulation results.
7.	Caution against acceptance of modelling and simulation results when there is insufficient evidence of thorough validation and verification.
8.	Assure thorough and unbiased interpretations and evaluations of the results of modelling and simulation studies.

Note that the term simulation in Table 1 may be removed (implying that the statement applies to mathematical modelling in general) or replaced by any other mathematical modelling technique. Furthermore, the original US spelling has been retained.

The section on Professional Competence of the Code of Professional Ethics for Simulationists gives useful but fairly general instructions. Table 2 gives more specific ethical (best-practice) guidelines relevant to the design of a scientific experiment as well as to the collection and analysis of data. These guidelines have been extracted from a web exposition provided by Mann [16]:

Table 2: Best-practice guidelines relevant to the design of an experiment and to the collection and analysis of data (extracted from [16])

1.	All results collected in an experiment, not only those that suit the researchers, should become observations in the subsequent analysis.
2.	Researchers should not allow a bias to be introduced into an experiment as a result of strong expectations on their part to achieve something. Such bias can lead to a failure to see certain non-conducive events or to see unreal ones.
3.	Data collected should be backed-up and preserved for an appropriate time period.
4.	Data should not be edited (falsified).
5.	Data should not be made up (fabricated).
6.	Appropriate commercial software should be used for modelling or analysis.
7.	Scientific judgement should be continuously applied during a study but any assumptions or decisions made, eg exclusions, should be reported.

Table 3 shows certain explicit items, relevant to mathematical or statistical modelling, which we have added to the checklist.

Table 3: Additional best-practice guidelines relevant to mathematical or statistical modelling

1.	An experiment which involves the collection from, and provision of data to, a number of participants and that has any claim to being representative, needs to be designed by statisticians or other people experienced in sampling in order to ensure that the selected sample is representative, and to ensure that all understand what population is being represented.
2.	The analytical methods used should be appropriate; if the analysis involves the construction of mathematical or statistical models, these models should be developed or supervised by skilled and experienced professionals and proper methodologies should be applied for their development and application.
3.	If commercial software is used to model or analyse situations such software should have been previously validated; if in doubt, different software packages should be compared and their results validated.
4.	There is a need to understand the risks and the benefits involved in the situation being modelled.

The issues listed in Tables 1, 2 and 3 have been used as a checklist for the professional conduct exhibited during the tracking project (see Section 5). Each of the codes and guidelines listed in these tables could have components of all three sub-categories of normative ethics, ie virtue ethics, deontological ethics and consequentialism (see section 2.1), but they appear to relate mainly to the deontological sub-category, ie to the various duties one should follow. While mainly deontological, and although not explicitly stated, it is probably because of their consequences that they have been proposed.

2.4. Ethics relevant to the treatment of research participants

The previous discussion on ethics dealt with professional competence and best practices and not with issues relevant to the rights and protection of research participants. Trochim [22] gives the following notions which address these issues (Table 4):

Table 4: Ethical notions addressing the treatment of research participants (synthesised from [22])

1.	**Voluntary participation**: Participation in research should not be coerced.
2.	**Informed consent**: Individuals must approve of their participation in the research and be given an explanation of the objectives of the research, their role in it and the risks they could be facing.
3.	**Avoidance of harm**: Any risk of harm to individuals, be it physical or psychological, that might arise during a research initiative, should be avoided.
4.	**Confidentiality and anonymity**: Research participants should be ensured that information pertaining to them could be shared with only a limited number of individuals directly involved in the research; anonymity helps protect the identity of a participant and is one way of ensuring confidentiality.

5.	**Institutional Review Board (IRB)**: The approval of an institutional committee, which considers the ethical implications of research projects involving humans or animals and reviews and approves such projects or proposals in a way which protects the institution, the researchers and other participants, should be obtained.	

Notions 1 and 2 in Table 4 relate mainly to the deontological sub-category of normative ethics, ie to duties, whereas notions 3 and 4 relate mainly to consequentialism, ie to the consequences of one's actions. Notion 5 relates to both. These notions have been used in Section 6 as a checklist for the treatment of participants during the tracking project.

2.5. Barriers to ethics in practice

Recently, some OR/MS scholars have dedicated efforts to promote ethics in the field. Le Menestrel *et al* [23] are promoting the integration of ethics into the OR/MS practice. As part of their work they have conducted a survey to identify barriers that could prevent this integration. The barriers they identified are presented in Table 5. They also grouped these barriers into types of barriers.

Table 5: Barriers to ethics

Conceptual and methodological	
1.	Ethics is not relevant in OR/MS
2.	Ethics is difficult to treat in OR/MS
Cultural, organisational and motivational (contextual)	
3.	The external context is not favourable
4.	Ethics conflicts with academic success
5.	Ethics conflicts with economic success
6.	Ethics requires time
Psychological and emotional	
7.	Psychological and emotional barriers

2.6. Ethics related to surveillance

According to Ball *et al* [24], the current society is a surveillance society, ranging from being monitored on closed-circuit television (CCTV) cameras in the inner-city to the use of loyalty cards. The authors do acknowledge that the surveillance society has its benefits, but that it has negative consequences such as abuse by governments, eg the US government when it singled out the Japanese Americans during the Second World War [24]. Another negative impact is that large companies profile buying patterns and credit worthiness of customers in order to create a profitable clientele base, which leads to the exclusion of other people that do not fit the so-called profile. Two of the authors have experienced such problems themselves, because they prefer not using credit. In other words, one only exists if the system can put one under surveillance. There can also be a social status to being recorded, because one can be 'found' – such as having an address, which not everyone in South Africa has as a result of apartheid, for example [25]. CCTV camera surveillance can unwittingly lead to incriminating and embarrassing information of individuals' conduct.

Ball, *et al*, [24] indicated three key areas of concern with regard to human rights and ethical issues in the realm of privacy of the individual in the surveillance society, which is given in Table 6 (numbers 1 to 3) below. Marx [26] proposed 29 questions for determining whether surveillance is ethical or not. He grouped the questions under three headings (see numbers 4, 5 and 6 in Table 6).

Table 6: Ethical issues with regards to surveillance (extracted from [24 & 26])

1.	The social exclusion and discrimination of individuals by varying the intensity of surveillance based on geography (ie bad neighbourhoods), social class, ethnicity (as referred to above) and gender.
2.	The limitation of choice, power and empowerment of individuals or groups.
3.	Lack of accountability and transparency.
4.	The Means: how the data are collected, ie does the collection pose any harm to the people under surveillance, cross personal boundaries without permission, break the trust of the person concerned or could the surveillance produce invalid results?
5.	The Data Collection Context: how is the technique applied and for which purposes will it be used? Examples are the awareness of participants that they are under surveillance; the rights to inspect the surveillance results, challenge the results and lay grievances; and the proper protection of the data and participant's identity.
6.	The Uses: the actual use of the collected data. Examples of questions asked here are: a. Who benefits from the collected data? b. Is there a clear link between the data collected and the goal sought? c. Are the collected data being used to the unfair disadvantage of a participant?

Marx [26] indicates that if the answers raise ethical concerns with the intended surveillance, these ethical concerns should be addressed first before the surveillance is conducted.

3. The GenDySI project

3.1. Background to the project

Constituted by an Act of the South African Parliament in 1945, the CSIR is one of the leading scientific and technological research, development and implementation organisations in Africa. During March 2005, the CSIR conducted an experiment to test the possibility of building transport models by tracking cell phones, and hence people, passively [27, 28 & 29]. The success of this experiment led to the more comprehensive project, GenDySI, *Generation and harnessing of DYnamic Spatial Intelligence* (long title: *Building a shared spatial data knowledge platform to harness real-time geocoded information of transport-spatial interaction*) [30]. Historically, the primary mechanisms for capturing travel data have been travel diaries and recall surveys, which are not accurate, are expensive, are difficult to use with illiterate commuters and experience resistance from commuters [31].

3.2. Event Personal Travel Advisor (E-PTA) pilot project

One of the GenDySI pilot projects was the Event Personal Travel Advisor (E-PTA), which aimed at active tracking of individuals going to and from an event, to provide them with useful information on current traffic conditions and directions to appropriate parking, etc.

Such events could be sports events, pop concerts or festivals, or anything likely to draw a significant crowd. The intention was that the messages would be computer-generated voice messages sent to the cell phones of the participants. A further objective was to test what impact a very large crowd would have on cellular network congestion, as this could severely limit the utility of tracking cell phones at an event with a large crowd.

3.3. The tracking component of E-PTA

Initially, the concept was to perform active tracking in real-time and link the results on a geographical information system (GIS) with traffic data from a metropolitan authority, but no live spatial traffic information system was available to us. Hence, we simulated this by having the participants generate the traffic reports themselves. The event selected was the Super 14 rugby match at Loftus Versfeld in Pretoria, South Africa, between the Bulls and the Cheetahs, at 17:00 on Saturday 10 February 2007. Fortunately, there was a sell-out crowd of about 50 000 spectators.

Ten cell phones were tracked at five-minute intervals between 15:00 and 20:00 on the day of the match (covering the journeys to and from the rugby match): one was used by a participant who walked, while the other participants were driven to the event. The latter were paired off with drivers, so that the participant could focus on the requirements of the experiment. To establish how accurate the tracking was, each participant (or scribe) kept a travel diary describing their route by means of way points and times. Four participants were also tracked using a device which recorded global positioning system (GPS) data and cell phone Mobile Measurement Report (MMR) data. Another participant used his own GPS device to record his track and made the data available. The participants also submitted and monitored traffic reports (as described in Section 3.5).

3.4. Cell phone tracking data

A wireless application service provider (WASP) was used to provide the tracking data for the cell phones. Each cell phone was “pinged” by the WASP to determine the identity of the cell (Cell ID) that it was using. Each Cell ID was converted into a location by using the coordinates of the centroid of the cell. These locations were then modelled in *Flowmap* [32], a package developed by Utrecht University in collaboration with the CSIR, for analysing and displaying flows between origins and destinations. Flowmap strung together the pings to “snap” them to the road network, to create the synthesised routes used by the participants – see [33] for a discussion of the results. These synthesised routes were compared to the travel diaries and GPS data to assess their accuracy and to refine the *Flowmap* model.

All the participants and their drivers were required to sign informed consent forms to participate in the study and they had to confirm their participation by responding to an SMS (Short Message Service) sent to them at the start of the study. The participants and/or the drivers were either members of the project team or colleagues at the CSIR familiar with the project, and they were also provided with a briefing session before the pilot commenced.

3.5. The messaging component of E-PTA

MobilED (Mobile Education) is a communications server allowing the transmission of information across various channels, using text-to-speech (TTS) engines, interactive voice response (IVR) applications, and standard text-based messaging services. MobilED was developed by the CSIR and the University of Art and Design Helsinki (UIAH) in Finland.

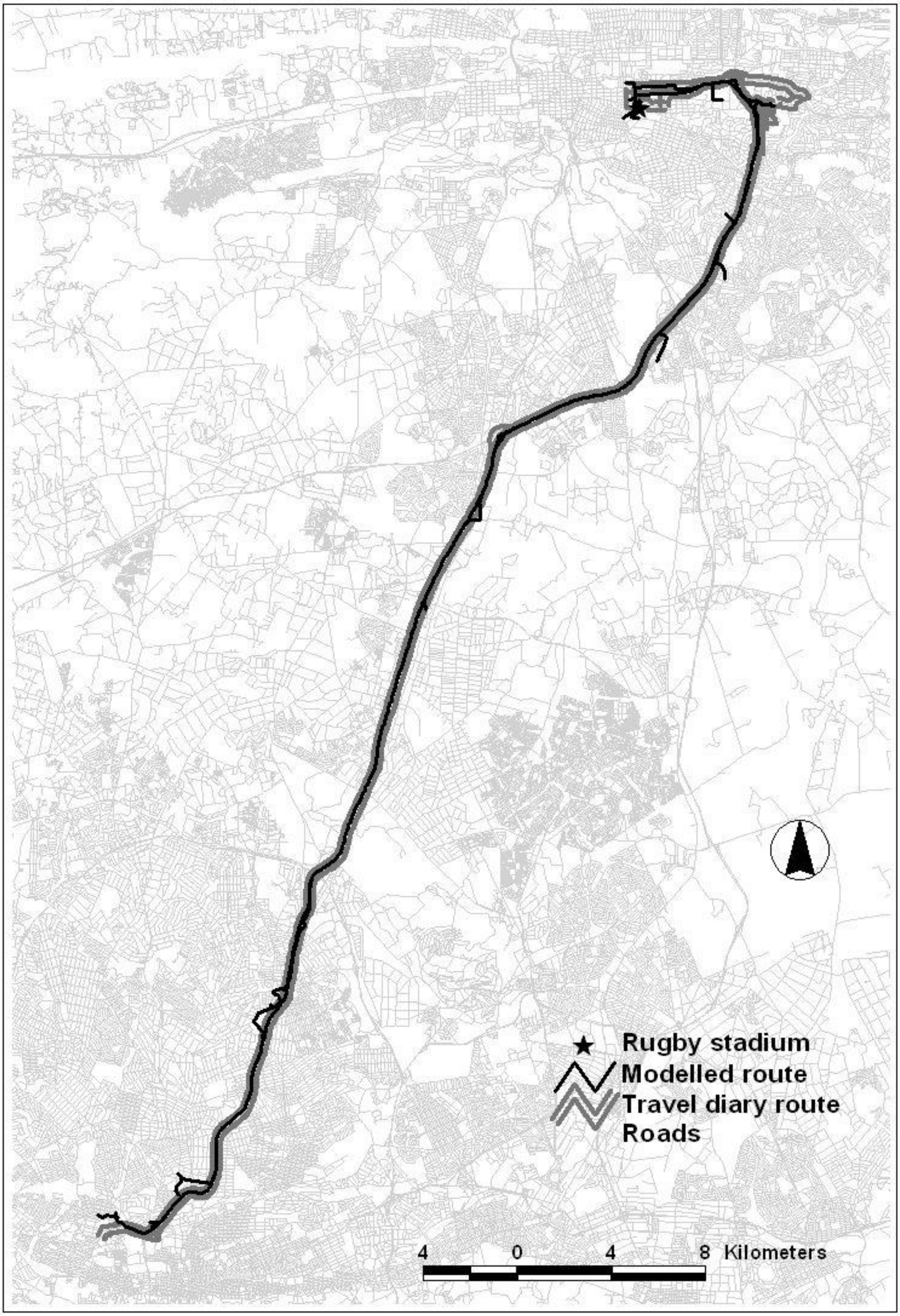

Figure 1: Participant's route from Johannesburg to the sporting event

For E-PTA, MobilED distributed the traffic alerts automatically to the participating cell phones. The disadvantages of text-based options such as SMS are they require the participant to read the message from their phone's screen, presenting ethical and other problems should they be driving (and hence liable to being distracted), and it would not necessarily provide real-time updates, as the user might not read the message immediately, effectively rendering it useless.

Hence, the solution is a standard audio call to the participant, who would be required to use a hands-free kit should they be driving. The traffic alert would be read to them using either a TTS engine (for dynamic, unassisted content) or a recording (for content moderated by human operators). For E-PTA, we used TTS. Apart from answering the phone, no interaction is required from a driver – this allows them to concentrate on driving the vehicle [34].

3.6. Research ethics review

In drafting the original proposal, we were conscious that the project could raise concerns over the invasion of people's privacy, as well as other ethical issues. We addressed this in two ways:

- Taking the pilot projects through formal ethical research review; and
- Researching some of the ethical, privacy and legal issues concerning GenDySI and other projects using location-aware technologies or digital geographical information [35].

When the project happened, the CSIR did not have a research ethics committee suitable for such projects. The University of Pretoria agreed we could use the Research Ethics Committee of their Faculty of Humanities. This formal ethical research review took longer than anticipated, because it was the first time the project team had done such an exercise, and the first time the University of Pretoria had allowed the CSIR to use one of its research ethics committees (other than for medical research). We were also conscious of doing the review properly, as we were pioneering the process for the CSIR.

The main focus of the review was ensuring there was proper informed consent from the volunteers who were tracked. It is our understanding that the quality of the documentation, the responses to the questions of the committee and the approach to the review were significantly better than average for research projects within the University of Pretoria.

4. Project results

As discussed in Section 3.4, the Cell ID coordinates were used to model the tracks of the participants using *Flowmap*. The results were exported into a GIS to map them. Figure 1 shows a fairly accurate modelled track in comparison to the travel diary, owing to the participant driving along a highway at high speed, which gave a significant distance between respective pings.

Figure 2 shows the results of modelling a person walking to the event. Owing to the walking speed, the high density of cells and the noise generated by the buildings (*canyon effects* and reflections), an erratic walking track was modelled in comparison to the actual route walked. The tracking of pedestrians needs much further research work.

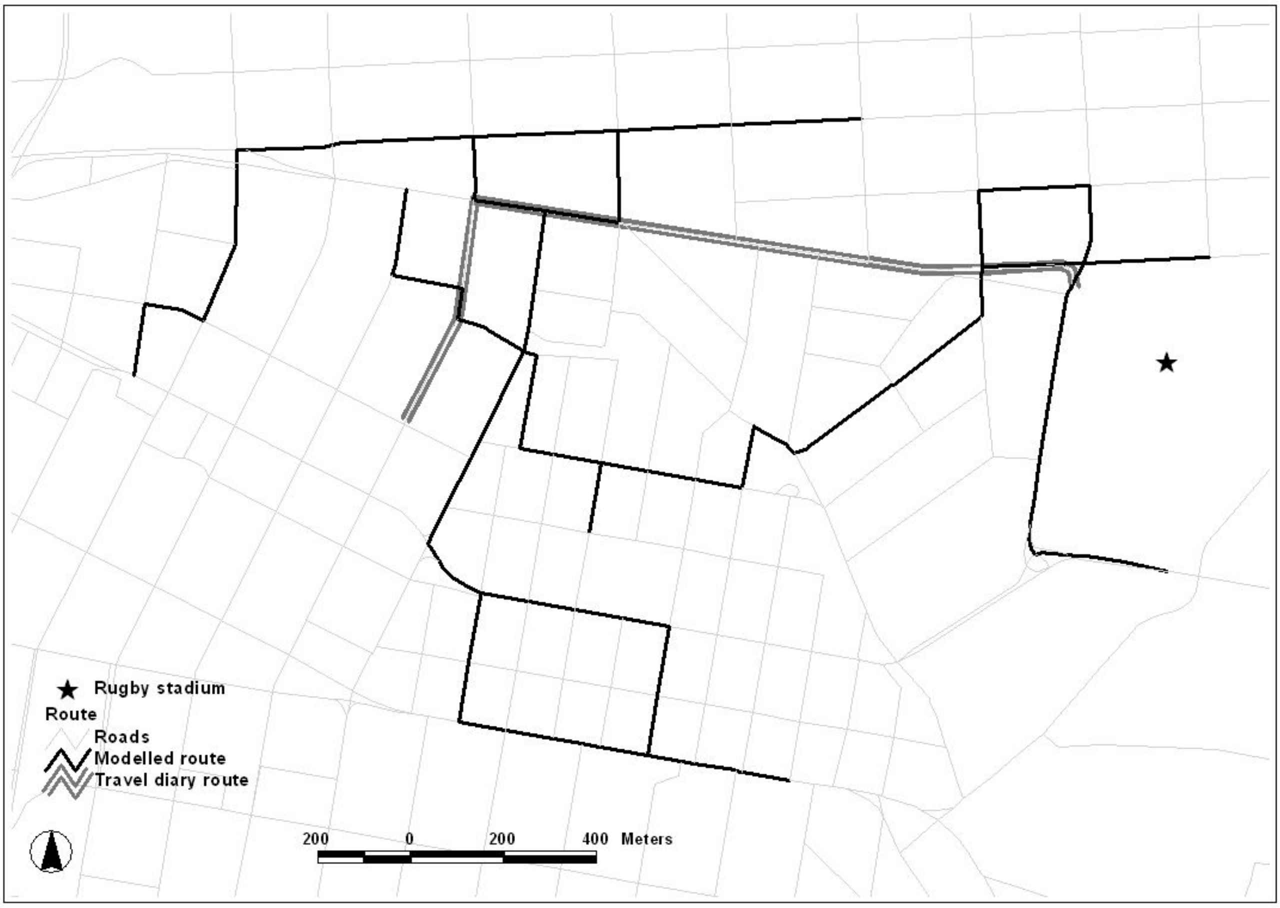

Figure 2: Participant walking to the event

5. Ethics of the modelling used in E-PTA

The practices used for the design of the E-PTA experiment, its execution and subsequent analysis and reporting were later checked against the guidelines provided in Tables 1, 2 and 3, leading to the following conclusions:

- The E-PTA pilot project had a clear objective intended for the convenience of spectators at events. A further technological objective was to test the impact of a large crowd on cell network congestion. Finally, E-PTA was to test the viability of distributing traffic alerts via synthesised voice calls to cell phones (Table 1, item 3).

- The GenDySI project as a whole was subjected to a professional review before it was selected for funding. The project team interacted with various experts outside the CSIR as the pilot projects were refined before being conducted (Table 1, item 2).

- The E-PTA experiment and its results were documented comprehensively in project reports (Table 1, item 4)

- Design assumptions, limitations and problems experienced during the E-PTA experiment were disclosed in the project reports (Table 1, item 5).

- We do not believe that there was bias as a result of strong expectations to achieve something, with the project showing that certain processes favoured by team members were unlikely to be viable (Table 2, item 2).

- We believe that appropriate scientific judgement was used throughout the E-PTA experiment and subsequent analysis and reporting. Further, no data were excluded (Table 2, item 7).

- We believe we adhered to best practices relevant to the design of the E-PTA experiment and subsequent analysis. This was helped by having a multi-disciplinary team bringing different perspectives, including experts sceptical about our likely success, who hence ensured the results were defendable. Regular project meetings were held for reviewing the project and our approach. The Research Ethics Committee complimented our approach to the pilot projects (Table 1, items 1, 6, 7 and 8; Table 2, items 1, 3, 4, 5 and 6; and Table 3, item 1).

- The E-PTA project did not use a representative sample, did not try to do so and did not claim to do so, as this was not necessary for the testing (Table 3, item 1).

- In modelling the tracks of the participants the software tool *Flowmap* was used. This tool had been validated on numerous previous occasions and the user/modeller was familiar with the tool (Table 3, items 2 and 3).

- The results of the modelling were shared with each individual participant. Any differences or deviations between the simulated and actual results were discussed with them, to try to explain the difference. The detailed data collected have not been published for reasons of confidentiality, though they are being retained for at least five years, as required by the research ethics review. The team also followed the two principles as suggested by Gallo [12], the responsibility principle and the sharing and cooperation principle (see Section 2.1).

- In considering the barriers to ethics, we believe that ethics is relevant in OR/MS and is not difficult to treat in OR/MS (Table 5, items 1 and 2), but ethics does have a cost (it limits the short cuts!) and does require time (Table 5, items 5 and 6), at least initially – in our case, taking the pilot projects through the Research Ethics Committee delayed the pilot projects by at least six months, though much of that delay was because of our lack of experience with the processes. Academic success *should* require adherence to ethics, particularly to ensure the veracity of the results (Table 5, item 4). Of itself, of course, this paper shows that ethics can contribute to academic success! Project team members could differ on approaches to a project and the ethics of the options – creating psychological barriers (Table 5, item 7), which could create conflict and hamper the project. The ethical issues should be considered up front before the project commences, so that either the project could be rejected or the project team selected carefully. External pressures could require a project team to work on projects they find unethical (Table 5, item 3) – fortunately, it has not been an issue for us.

6. Ethics related to the treatment of research participants in E-PTA

Ethical issues relevant to the rights and protection of research participants in the E-PTA study were later checked against the guidelines provided in Table 4, leading to the following conclusions:

- The Research Ethics Committee of the Faculty of Humanities at the University of Pretoria reviewed and approved the study (Table 4, item 5).

- Participation in the study was voluntary and informed consent was obtained from all participants (Table 4, items 1 and 2).

- Confidentiality issues include the possibilities people forget they are being tracked or they unwittingly agreed to be tracked. In the debriefings for E-PTA, several participants revealed they forgot at some stage they were being tracked, particularly between arriving at their destination after the game (eg: home) and the end of the monitoring at 20:00. The modelled routes included these post-event travels, though nothing compromising. This could be addressed by providing regular reminders to the participant about the tracking, allowing a participant to terminate the track (which was an option in GenDySI), and/or providing a finer cut-off time for the tracking, though this would have lost some of the relevant data, and actually revealed roads missing from the data set (Table 4, item 4).

- Risk of harm of the participants in E-PTA was minimal. This could become an issue, however, in a larger pilot study or after commercialisation of an E-PTA-type product. Such risks could entail providing the participant with inaccurate or inaudible traffic information, resulting in distress or missing the event; or distracting them while driving. There could also be a risk of using information collected as evidence against the participants, eg accusing them of speeding or of being at a crime scene or a disreputable venue (Table 3, item 4 and Table 4, item 3).

7. Ethics related to surveillance in the E-PTA experiment

Ethical issues regarding the surveillance of the participants in the E-PTA experiment were later checked against the guidelines provided in Table 6, leading to the following conclusions:

- The varying intensity of surveillance in the project was because of the availability of the equipment and was not based on social exclusion (Table 6, item 1). Selection based on geography was done to test the accuracy of the tracking over long distances.

- All the participants volunteered to participate in E-PTA, were aware of being tracked, could withdraw at any time, even in the middle of the tracking, and were given the results afterwards (Table 6, items 2, 3 and 5).

- Regarding the surveillance, the risk of harm was also minimal since the surveillance was passive and the locations modelled are coarse at the end of a track. The participants were aware of the surveillance (though some forgot they were still being tracked after the event) and the data were used as initially proposed (Table 6, items 3, 4, and 5).

- The experiment was to test methods and technology and hence was conducted with few participants in a personal setting. Hence, the modelling produced variable results, identifying where the technique is likely to break down, namely when the cell phone is moving slowly through an area of high cell density (Table 6, item 4).

- The participants were made aware of the uses of the collected data, that the results of the study will be used in scientific publications, and of the steps taken to protect confidentiality (Table 6, items 3 and 6).

From the above, we believe that the surveillance was conducted in an ethical way, bearing in mind that the project team did not at that stage have the guidelines of Ball, *et al* [24] and Marx [26]. Our assessment against the checklist in Table 6 and the clearance of the project by a research ethics committee, clearly show that the project team was very sensitive to the ethical issues relating to surveillance to ensure that the privacy of the participants was not breached.

8. Ethics related to sending messages to drivers

In E-PTA, care was taken to ensure the participants were not driving during the experiment, so they could maintain their travel diary, send and receive traffic alerts, and maintain a log of messages. These tasks were quite demanding, and would have been impossible for a driver to perform. Hence, we did not assess the utility of traffic messages sent to drivers. Nevertheless, we identified several ethical issues that should be considered:

- Subscribers to such a service should agree in advance to use hands-free kits when they are driving (or use their passengers), but will they actually do so?

- The quality of the voice messages – will they be a distraction or an aid? For E-PTA, an American TTS voice was used, as the local ones (eg: South African English) did not have a large enough vocabulary at the time. The American TTS did not pronounce some street names well, though this can be fixed through pronunciation rules for local names. Sometimes, there was much ambient noise when the message was received, particularly close to the stadium. Both of these meant that participants had to listen to some messages several times to understand them.

- What would constitute too many messages for a driver, becoming a distraction?

- What if a subscriber expects to get a message (such as when first entering the area covered, or not having received one for ‘a long time’), but there is nothing useful to send? Should they get a bland message (eg: “traffic running smoothly”) in any case? What would constitute too few messages being sent to a driver?

- What information is useful to send? It might also be important to send out messages cancelling earlier alerts.

Such a messaging service would not be limited to events, but could be used for areas where there often are traffic problems, such as tricky mountain passes. In some countries this could be done with Radio Data System (RDS), but that is not used in South Africa. Some of these ethical issues mentioned above might also apply to RDS messages.

9. Conclusions

We have reported here on an experiment conducted by the CSIR to track the cell phones of a small group of people as they moved to and from the event, to assess the viability of using such tracking to provide the participants with useful traffic information. More relevantly, we have reported on the ethical issues raised by such tracking. We have conducted a review of the ethics of modelling and of surveillance, considering issues such as:

- Definition of, and approaches to, ethics;
- Implicit adherence to ethics through the use of professional good practices for one's discipline;
- Ethical transgressions in research;
- Codes of professional ethics;
- Best-practice guidelines;
- Treatment of research participants;
- Barriers to ethics in practice; and
- Ethics related to surveillance.

We then used the results of the review to assemble check lists of relevant ethical issues, adding a few of our own, against which the conduct of a research project could be assessed (ie: a deontological ethics approach). Of course, check lists are not necessarily required for a project to be executed ethically – in our case, we used virtue ethics and consequentialism intuitively for the project. Such deontological ethics alone cannot guarantee that a project will be executed ethically, but they can give one peace of mind that one is probably doing the correct thing. The project was subsequently described and assessed against these check lists. The assessment led to the following conclusions:

- In general, there was compliance with professional codes and best practice guidelines, covering modelling, surveillance, data collection, and treatment of research participants;
- The project team followed the two principles suggested by Gallo [12], the responsibility principle and the sharing and cooperation principle (see Section 2.1);
- The treatment of research participants was done in an ethical way with clearance by a research ethics committee, voluntary participation and informed consent;
- Confidentiality issues, such as whether or not one remembers that one has given consent, were identified and possible solutions proposed;
- Risk of harm to the participants was minimal but could increase in the case of a larger scale project, such as not meeting the expectations of participants;
- Although we did not assess the utility of traffic messages sent to drivers, we nevertheless identified several ethical issues that should be considered.

It should be borne in mind that the authors reviewed the literature on ethics, and ethics of research, modelling and surveillance in particular, after the completion of the E-PTA experiment. Instead, they had to rely on the useful recommendations of a research ethics committee and their professional judgement. Despite this, the various ethical principles and guidelines listed in the literature were fairly adhered to. Like Gass [8], we feel quite strongly that a code of ethics is required for modellers but through our training and experience we probably "just knew what was right and what was wrong" concerning ethics (see Section 2.1). Having said this, we believe that our exposure to the formal notions of ethics has been extremely beneficial and it is, therefore, highly recommended to all our colleagues engaged in the quantitative disciplines.

Some of the barriers to ethics listed in Table 5 are not to be underestimated. For example, the subjective nature of what is virtuous, or what constitutes good or bad, or how one should weigh consequences can be functions of time and space, of culture or religion. We also understand that a direct discussion of ethical issues may be considered taboo by some colleagues and met with resistance. However, we currently have the advantage of having much more information available to us than all previous generations put together to enable us to invest some time to reflect on ethics in our professions.

10. Acknowledgements

The authors would like to thank the CSIR for funding this research through its Strategic Research Panel, project number PPTH/2005/036, "*GenDySI (Generation and Harnessing of Dynamic Spatial Intelligence)*". We would also like to acknowledge the advice on ethics provided by Professors Brenda Louw and Deon Rossouw (University of Pretoria) and Johan Hattingh (University of Stellenbosch), and thank the participants in the E-PTA pilot project. Finally, we would like to acknowledge the anonymous referees and the editors of this special edition for their insightful comments, which have helped us improve the paper significantly. A preliminary version of this paper was presented at IFORS 2008 [36].

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