Exposure of the road network to direct sunlight: a spatiotemporal analysis using GIS and spatial video

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ABSTRACT

The direct sunlight hides risks when a vehicle is moving on the roads during summer, as the position of the sun can block a large amount of drivers’ visibility. This paper presents a methodology for validating/calibrating the primary results of a GIS-based spatiotemporal analysis of direct sunlight throughout a rural road with the use of spatial video. The study area is Rethimno, Greece, and the data used for this simulation is the topography, the road network and the sun position for a specific time during summer. The results of the simulation are illustrated on a risk map which indicates segments of roads at high risk in terms of direct sunlight. Moreover, the results have been tested, validated and calibrated in situ. A specialized car with a video camera and a Real Time Kinematic GPS on board was used to evaluate the primary results of the simulation. The ability of the spatial video to validate GIS-based modeling of moving vehicles is a valuable result of this work. Applying the analysis for long time periods, may lead to prevention policies adoption related to accidents of direct exposure to sunlight. Furthermore, this methodology could be an additional module in car navigation systems.

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Introduction

Videography is the process and set of methods and operations that are used to capture a sequence of moving images (Kiger 1972; Lewis, Fotheringham, and Winstanley 2011). Beside the classical videography, nowadays a specific application called spatial video is used for a variety of applications with geographic reference.

Spatially encoded video can be used in every phenomenon that has spatial referencing. Even in those that there are not a priori obvious, such as a paradigm of social science research (Rosenstein 2002) where three methodological approaches of videography in general (observation, feedback and distance learning) have been suggested.

Consequently, spatial video has a number of approaches that stand for academic or other (e.g. commercial) use. Lewis, Fotheringham, and Winstanley (2011) have ended up into two main approaches; one which is based on the prevailing methods of modelling spatial video in existing commercial and academic applications and the other which considers a GIS-based spatial data interaction environment.

There are many examples involving spatial video with the geographical space such as in cartography (Hirose, Watanabe, and Endo 1998; Kawasaki et al. 1999; McCarthy 1999), in visual analysis (McLoughlin et al. 2005; Ó Riain and McCarthy 2009) and in validating the geographical content (Hirose, Watanabe, and Endo 1998; Navarrete and Blat 2002; Nobre and Camara 2001). Many scientists are using techniques which involve video with spatial referencing for data collection in a variety of applications (Mills et al. 2010).

An important serviceableness of spatial video is in post-disaster environment for capturing video data related to disasters (Curtis and Mills 2012; Curtis et al. 2010, 2007; Lue, Wilson, and Curtis 2014; Mills et al. 2008a), such as the Katrina Hurricane (Mills et al. 2008b) where spatial data were collected for non-public consumption. These applications have led (together with the innovations of technology) to the so-called neogeography which enables public involvement with spatial data through the internet (Curtis and Mills 2012).

This current paper presents a methodology which uses spatial video in order to validate and calibrate the results of a GIS-based modelling. In order to succeed this, an application of modelling the direct sunlight on rural road network through solar radiation analysis using GIS was selected. The direct sunlight was computed through solar radiation, which is the...
energy given off by the sun and is made up of electromagnetic waves. This incoming solar radiation is modified as it travels through the earth atmosphere and again once it hits the surface giving the three main components of solar radiation which are the direct, the diffused and the reflected solar radiation. This global solar radiation can be used in predictions of various phenomena such as the design of solar energy systems (Pons and Ninyerola 2008) and estimations of the thermal environment within buildings (Vargues and Loures 2008).

Nowadays, it is commonly accepted that the GIS technology can be used in order to simulate various phenomena. They give the advantage for fast results throughout the simulations, which extends from the data management to the analysis and the visualization of them (Longley et al. 2005). This is an ongoing evolving technology which enables users to edit high volume of data and offers the ability for applications in many different fields of science. GIS is also a technology that provides well-organized possibilities for the analysis of phenomena which are variable in space and time. This variability can be simulated in a GIS environment and can also be captured with a spatial video in order to evaluate the GIS simulation.

In this work, an aspect of road accident risk was evaluated in terms of the exposure to direct sunlight. Road segments of a specific route were recorded with a vehicle which had on board a video camera and a Real Time Kinematic GPS. For each point of the road segments, the position (x, y and z coordinates) and the section of the road that was visible to the driver of the vehicle were recorded. The exposure to direct sunlight is a spatiotemporal phenomenon due to the continuous change of sun’s position and the motion of a vehicle on a road (Chalkias and Faka 2010). Road risk accident analysis may concern the study both of accidents that had already occurred in an area and of risk factors that may be directly related to the occurrence of accidents (Contini et al. 2000; Loo 2006). In fact, this is part of the public health approach which is not only helpful in the analysis of a specific risk factor in transportations, but it also provides a framework for decision-making throughout its entire process, from identifying a problem to developing intervention procedures (Peden et al. 2004; Tiwari 2003).

Furthermore, road risk analysis can reveal high crash zones either between vehicles or in accidents which involve pedestrians (Pulugurtha et al. 2007; Curtis et al. 2007). Studies have also implemented GIS technology and Google Earth in order for road accidents georeferencing (Ferreira and Ferreira 2011). A potential outcome of the proposed analysis is the prevention of accidents in rural road network. Hence, road risk analysis by managing geographic data could be integrated in road network planning projects (Lambert, Peterson, and Joshi 2006; Rodrigues, Ribeiro, and Da Silva Nogueira 2015; Zhang, Lippitt, and Bogus 2017).

Materials and methods

Spatial data

One very important spatial data set for this methodology is Digital Elevation Model (DEM) of the study area. The DEM is an earth surface 3D model which represents ground surface including the elevation of plants, buildings and other artificial objects. The lack of those kinds of data led to the adoption of Digital Terrain Model (DTM) which represents the bare ground surface. The terrain model was created using contour lines (contour line interval: 20 m), trigonometric and elevation points, and the stream network, which were digitized from topographic analogue maps of Hellenic Military Geographical Service. The DTM was created in ArcGIS version 10.2 (ESRI Inc., Redlands, California, U.S.A.) using the ANUDEM algorithm (Hutchinson 1989) with spatial resolution 20 × 20 m.

Another spatial data set required for this analysis, concerns the road network of the study area. In this study, a specific route was selected which was derived by vehicle tracking data. These data were recorded using a Real Time Kinematic GPS at sampling interval of one second. Alongside the recording of route’s geometry, the route was filmed by positioning a camera in the front glass of the vehicle. This video shows second by second the real exposure to direct sunlight for the specific time period and it will be used to validate the results of the analysis.

Sun position data

Data reflecting sun position during a specific time period were obtained from the astronomical server of United States Naval Observatory (USNO) (http://aa.usno.navy.mil/data/docs/RS_OneDay.php). These data provide information about the solar altitude and azimuth angles. Altitude of the sun is the angle above the horizon whereas azimuth corresponds to the direction of the sun measured clockwise from the North. Both altitude and azimuth are measured in decimal degrees. The parameters required for the calculation of sun position are geographical coordinates (Lat, Lon) of the study area, the date and the time interval (Chalkias, Psiloglou, and Mitrou 2006).
The data concerning the position of the sun over the route’s time period recording are presented in Table 1. The route duration is 18 min, from 16:27 am to 16:45 am at 25 July 2012 (time interval: 1 min).

**Spatial video – the GPS and video cameras installation**

In this work, we performed measurements with moving GPS (VU) on the road part of the study area. We used two GPS devices positioned at a fixed distance and zero height difference between them (Figure 1), in order to allow immediate quality control of measured points. Also, we had the possibility of taking differential corrections from two different GPRS signal providers eliminating the lack of correction signal. At the same time beside the Real-Time (RTK) measurements satellite frequency observations of 1 s were recorded, enabling in this way the ‘aftertreatment’, where the GPRS signal could not be obtained.

The accuracy of measurements (which were made with dual frequency GPS), in plan view, is of the order of 1 m and made with the implementation of the differential detection through the use of Greek Positioning System (HEPOS). In places where there was no satellite visibility (e.g. due to dense vegetation, natural gorge or technical work) and especially in mountainous segments of road with high altitude (e.g. greater than 1000 m.) due to lack of GPRS signal, it was not possible to obtain differential corrections in the case of the method of Contemporary kinematics measurements (Measurements Real-Time or commonly RTK). The mean error of the observations was less than 0.5 m (the average horizontal alignment error was 0.18 m for the time in which the vehicle was stationary and 0.37 m for the period in which the vehicle was moving). Also, the errors were greater than 2 m in places where visibility was difficult due to invisibility of satellites.

To determine the horizontal and vertical geometry of the road, we used two GPS receivers (TOPCON GR-3, STONEX S9 GNSS) on a vehicle behind two digital video cameras (Figure 1). Actually, we used two dual frequency geodetic GPS anchored at fixed points in the roof of the vehicle at a constant distance between the two antennas (the antenna heights were measured using a conventional total station being in

### Table 1. Sun position data: solar azimuth and altitude for Rethimno (E24° 47', N35° 29'), Zone: 2 h East of Greenwich.

| hour:minutes | Altitude (°) | Azimuth (°) |
|--------------|-------------|-------------|
| 16:27        | 35.4        | 269.8       |
| 16:28        | 35.2        | 269.9       |
| 16:29        | 35.0        | 270.1       |
| 16:30        | 34.8        | 270.2       |
| 16:31        | 34.6        | 270.4       |
| 16:32        | 34.4        | 270.5       |
| 16:33        | 34.2        | 270.7       |
| 16:34        | 33.9        | 270.8       |
| 16:35        | 33.7        | 270.9       |
| 16:36        | 33.5        | 271.1       |
| 16:37        | 33.3        | 271.2       |
| 16:38        | 33.1        | 271.4       |
| 16:39        | 32.9        | 271.5       |
| 16:40        | 32.7        | 271.7       |
| 16:41        | 32.5        | 271.8       |
| 16:42        | 32.3        | 271.9       |
| 16:43        | 32.1        | 272.1       |
| 16:44        | 31.9        | 272.2       |
| 16:45        | 31.7        | 272.4       |

Figure 1. Installation of GPS receivers and digital video cameras in the roof of the vehicle.
measurement conditions, i.e. three people inside the vehicle with the necessary equipment). More details in the aforementioned measuring-recording system were the following:

- Fixed distance between the satellite antennas in order to have quality control of the reliability of measured points.
- Fixed distances between satellite dishes and of assigned borderline.
- Fixed height of the antennas from the deck of the road.
- Dual GPS for simultaneous observation time points.
- Double GPRS different provider at GPS, for reduction of road sections with insufficient differential corrections transmission signal.

The characteristics and the type of the instruments that were used are listed in Table 2.

For the final export of the road axis, the above-mentioned measuring system was combined with appropriate background orthophotos. In fact, the axis of the road from the successive points of GPS were compared to that on the above orthophotos. With the export of the finished road, which was emerged from the set of points that were measured with both GPS regardless of the measurement accuracy, those points were used to georeference the video. With this operation it was ensured that there were filming points which were georeferenced at entire length of sub channels and study within the respective accuracies. In order to export the altimetry of the road axis, the measured points of the two GPS were used.

For the validation of the geometry, using the analysis of raw GPS data (of the two GPS), the points with HRMS <1.5 m were used (in difficult areas were used points with HRMS <3.0 m). The statistical analysis of the data for the entire study area is presented in Table 3.

It is obvious that the points with HRMS <1.5 m are 98.5% for STONEX GPS and 88.54% for the PM 200 GPS. That means that the achieved accuracy is overlying the accuracy purposes of this study.

**Road segment exposure to direct sunlight**

The proposed methodology uses fundamental GIS functions in order to estimate the direct sunlight on road network (Figure 2).

Initially, the spatial database consisting of the following primary GIS layers has to be constructed:

- Contour lines (line topology)
- Elevation points (point topology)
- Stream network (line topology)
- Mainland (polygon topology)
- Road network (point topology)

The post processing of the first four layers within GIS environment produce the DTM of the study area, while the road network topology converted from point to line so that the segments gain a fixed geometry that corresponds to a temporal interval of the video (one second). This procedure created straight line segments with constant azimuth and length ≤10 m. The values of height for each node of the road network were based on the relief of the area (DTM).

Next, a set of hillshade layers was produced in order to identify shaded areas. The creation of a hillshade layer is based on the relief of the area (DTM) and sun position data for a specific time. Each hillshade layer was used to classify the corresponding road segments,

| Model       | GR-3           | S9 GNSS       |
|-------------|----------------|---------------|
| Number of bands | L1, L2, & L5, CA, L1P, L2P, L2C | L1, L2, & L5, CA, L1P, L2P, L2C |
| GPS         |                |               |
| GLONASS     |                |               |
| GALILEO     |                |               |
| WAAS/EGNOS  | YES            | YES           |
| Real-time DGPS accuracy | H: 10 mm+ 1 ppm V: 15 mm+ 1 ppm | H: 10 mm+ 1 ppm V: 20 mm+ 1 ppm |
| Post Processed Static DGPS | H: 3 mm+ 0.5 ppm V: 5 mm+ 0.5 ppm | H: 3 mm+ 0.5 ppm V: 5 mm+ 0.5 ppm |
| Radio modem |                |               |
| GSM/GPRS modem | Built using sim card | Integrated Tx/Rx selectable from 0.01 to 1 W |
| Bluetooth   | YES            | YES           |
| Data recording rate | 1–100 Hz      | 1–100 Hz      |

**Table 3. Horizontal errors of the used GPS.**

| HRMS         | STONEX | % POINTS | PM 200 | % POINTS |
|--------------|--------|----------|--------|----------|
| HRMS <0.10 m | 32,158 | 83.30    | 34,653 | 49.83    |
| HRMS <0.50 m | 35,038 | 90.76    | 44,739 | 64.33    |
| HRMS <1.0 m  | 37,111 | 96.13    | 54,897 | 78.93    |
| HRMS <1.1 m  | 37,467 | 97.05    | 56,533 | 81.29    |
| HRMS <1.2 m  | 37,709 | 97.68    | 57,94  | 83.31    |
| HRMS <1.5 m  | 38,026 | 98.50    | 61,58  | 88.54    |
| HRMS <2.0 m  | 38,527 | 99.80    | 65,53  | 94.22    |
| HRMS <3.0 m  | 38,606 | 100.00   | 69,548 | 100.00   |

It is obvious that the points with HRMS <1.5 m are 98.5% for STONEX GPS and 88.54% for the PM 200 GPS.
to shaded or not shaded, during the route which was recorded in spatial video.

At the final step, the direction and the gradient of each road segment were compared with the solar azimuth and altitude, respectively, in order to be classified according to the exposure to direct sunlight. The azimuth (direction) and the gradient of each road segment were calculated from the \((x, y, z)\) coordinates of the nodes for each line entity. From this last check, roads segments that were not under shadow and have identical direction (\(\pm \phi^\circ\)) with the sun azimuth and identical gradient (\(\pm k^\circ\)) with the sun altitude were characterized as roads at risk.

**Calibration of the camera**

To calibrate the horizontal angle of view, the direct sunlight algorithm was adapted so the road segments would be considered that are in risk, only if the segments were not shadowed and have identical direction (\(\pm \phi^\circ\)) with the sun azimuth.

Initially, a sample of road segments was selected systematically with a step of 10 s and each sampled segment was classified according to direct sunlight exposure based on video snapshots. The direct sunlight exposure was confirmed when the solar cycle covered \(\geq 40\%\) of the video snapshot. This sample was used as the basis of the evaluation for each horizontal angle tolerance (\(\pm \phi^\circ\)) were tested.

Afterwards, a step-wise trial and error method was implemented using different angle tolerance in order to quantify the quality of the results in comparison with the sample. The measurement of the accuracy of the algorithm was based on the harmonic mean (F-score) which is calculated as

\[
F = 2 \times \frac{\text{precision} \times \text{recall}}{\text{precision} + \text{recall}}
\]

where

\[
\text{precision} = \frac{TP}{TP + FP}
\]

and

\[
\text{recall} = \frac{TP}{TP + FN}
\]

Precision is a measure of exactness that corresponds to the number of false positives (FP) cases and recall is a measure of completeness that reflects true positives cases (TP). False negative (FN) cases are those that were not identified as segments at risk but should have been. F1 returns a score of 1 when precision and recall are both perfect, and approaches 0 when precision and recall are poor. The angle tolerance with the best F-score corresponds to the horizontal angle of

*Figure 2. Flowchart of the proposed methodology.*
view. The F-score has been also used for the evaluation of named entity recognition (Han, Wong, and Chao 2013) and machine learning (Powers 2011).

The final step concerned the calibration of the vertical angle of view according to the direct sunlight algorithm and the horizontal angle tolerance that was estimated previously. The evaluation of the vertical angle tolerance was based on the comparison of the output with the classified road segments, assuming that only hillshade and segment azimuth (± φ°) affect the road exposure to direct sunlight. Utilizing the same trial and error method as described above, the vertical angle of view was selected as the angle tolerance (± k°) with an F-score of 1.

**Study area**

A specific route on the rural road network of Rethimno prefecture was selected for the implementation of the GIS modelling. The prefecture of Rethimno is located in Crete island with latitude 35°29′ North and longitude 24°47′ East (Figure 3). It is one of the four prefectures of the region of Crete with an area of approximately 1.500 km² and permanent population of 85,609 inhabitants (Statistical Authority of Greece 2011).

Rethimno is a popular tourist destination of Greece. The economy of the area is strongly related to tourism and the population of the island is highly increased in summer time due to massive arrival of tourists. The touristic season lasts almost seven months (April to October), while the tourist arrivals are being increased significantly during June, July and August.

The morphology of the prefecture is described mostly as mountainous and hilly, whereas flat areas are confined to the northern and southern coasts. However, there is a wide developed road network across the whole prefecture. Due to the topography, many parts of the road network are narrow with sharp bends, and the road infrastructure can be characterized rather ageing despite the various maintenance and improvement activities (Michalodimitrakis et al. 2005). It is characteristic that the road conditions are one of the main causes of road traffic accidents in Crete (Vourvahakis et al. 2010), while high frequency of traffic accidents has been noticed during the peak tourist season.

**Results**

The methodology described previously was applied in the selected route at Rethimno area in order to analyse the exposure of road segments to direct sunlight. The results for the route on 25 July 2012 are presented in Figure 3. The route starts from point A at 16:27 am and ends at point B at 16.45 am.

The selected route at Rethimno was created by joining the recorded points from GPS and it consisted of 1062 straight-line road segments with 6.5 km of total length. The route lasted 18 min and every second corresponded to a road segment.

The calibration of the horizontal and vertical angles of the camera view provided the tolerance angles of solar azimuth and altitude correspondingly. Horizontal angle tolerance calibration followed ten degrees-step trials from ±20° to ±50°. Harmonic mean was calculated for every trial comparing the outputs of direct sunlight method with snapshots from the video. The results of

![Figure 3. Route at Rethimno area: road segments with high exposure to direct sunlight on 25 July 2012.](image)
harmonic mean indicated that horizontal angle tolerance ±40° followed the best way the video route’s direct sunlight exposure (Table 4).

The vertical angle tolerance calibration followed five degrees-step trials from ±20° to ±40°. Harmonic mean was calculated for every trial comparing the outputs of direct sunlight method with the outputs of the horizontal angle tolerance ±40°. The values of harmonic mean at Table 4 show that vertical angle tolerance up to ±35° follows exactly the results of horizontal angle tolerance ±40°.

Following the analysis, the azimuth of the road network segments was compared with solar azimuth and altitude for every time snapshot. All road segments that have the same direction with solar azimuth (±40°) and the same slope with the altitude of the sun (±35°) were selected for the final check with the hillshade layers. As a result, the route segments located under shadows were excluded and all the segments that are highly exposed to direct sunlight remained (Figure 3).

Figure 3 shows up that the road segments under risk are oriented west. This is a quite reasonable result; just considering the south to north direction of the route and the time period of the day that the analysis took place.

According to the results, the first road segment under risk appears at the 5th minute from the 18-minute route. Some longest segments are shown up at the 7th and 8th minute with continuous direct sunlight for 100 m each. At the next three sections of the route, the risk is continuous for over than one minute. The first of these sections is from 9th to 12th minute along 730 m, while the route in the 13th minute seems to be out of risk. The second long section under risk starts from 14th minute and lasts for 1.5 min (340 m). The last 820 m of the route are the final section under risk. It starts in the late 15th minute and lasts till the end of the route.

Table 4. Results of the calibration procedure: success rates for each road segment category for various horizontal and vertical angle tolerance.

| Horizontal angle tolerance | Harmonic mean |
|---------------------------|---------------|
| 20°                       | 0.49          |
| 30°                       | 0.68          |
| 40°                       | 0.75          |
| 50°                       | 0.73          |

| Vertical angle tolerance  | Harmonic mean |
|---------------------------|---------------|
| 20°                       | 0.87          |
| 25°                       | 0.88          |
| 30°                       | 0.92          |
| 35°                       | 1.00          |
| 45°                       | 1.00          |

Table 5. Statistical data for road segments highly exposed to direct sunlight.

| Road segments | Total number of road segments | Total number of road segments at risk | Percentage of road segments at risk |
|---------------|------------------------------|---------------------------------------|-----------------------------------|
|               | 1062                         | 339                                   | 31.9                              |
|               | Total length of route (km)   | Length of route under risk (km)       | Percentage of route’s length under risk |
| 6.5           | 2.2                          |                                       | 33.4                              |
|               | Total duration of route (sec) | Duration of route under risk (sec)    | Percentage of route’s duration under risk |
| 1062          | 339                          |                                       | 31.9                              |

The statistical analysis of the results (Table 5) shows that 2.2 km of the route is exposed to direct sunlight. This length corresponds to 33.4% of the total route’s length. The total duration of route is 1062 s and in 339 s the sun disk appears in the camera frame. This means that as the vehicle is moving on the route, the driver faces direct sunlight for about 5.5 min (31.9% of the total time).

Conclusions

In summary, this study presents a methodology for validating/calibrating the primary results of a GIS-based spatiotemporal analysis of direct sunlight throughout a rural road with the use of spatial video. The method adopted in this paper used background data (road network, digital elevation model and its derivatives) and sun position data in combination with advanced GIS functionality for spatial analysis.

Many studies have already used GIS in road risk assessment (Harirforoush and Bellalite 2016; Li, Zhu, and Sui 2007), though, to the best of our knowledge, studies related to the proposed analysis or similar analyses are limited (Chalkias and Faka 2010). The most valuable result of this paper is the ability of a spatially tagged video to validate a GIS-based modelling of moving vehicles. The integration of GIS analysis for the assessment of the direct sunlight on road networks with the spatial video increased the accuracy of the dynamic modelling and mapping of the road segments at risk. The accuracy is related to the thresholds of the angles tolerance that were defined for the comparison of the direction and the gradient of each road segment with the solar azimuth and altitude, respectively. The use of thresholds in such analysis is necessary in order to overcome unclarities caused from errors in spatial layers as well as inaccuracies in sun position data. The precise threshold both of horizontal and vertical angle tolerance was calibrated using snapshots from the
spatial video. The lack of this video and the information it provided would probably lead to more assumptions related to the tolerance in both angles of solar azimuth and altitude.

The implementation of the method in Rethimno area revealed that for the selected route of 18 min duration on 25 July 2012 the driver is exposed to direct sunlight almost for 1/3 of the total route duration. The results of the analysis revealed that a driver’s block of visibility due to direct sunlight exposure can occur multiple times and last for quite enough seconds even during a short route. This may be rather dangerous for every driver, especially for them who drive on unfamiliar roads, such as tourists and visitors.

Regarding the analysis scale, the proposed methodology can be also applied in more detailed analysis at local level. Despite the fact that the 20-m cell size of the DTM used for this application is considered suitable for analysis scales at regional level (1:50,000–1:100,000), more detailed analysis at local level spatial datasets with higher resolution are required.

Whether the risk of road accidents is increased due to the increased exposure is related to some assumptions and limitations of the study. The use of DTM which represents the bare ground surface led to the absence of special on-site conditions affecting the direct sunlight (high vegetation, trees, buildings/constructions, etc.). The adoption of DEM that represents ground surface including the elevation of plants, buildings and other artificial objects could overcome this limitation. The absence of atmospheric effects such as clouds and forms of precipitation is another assumption of this work. This analysis evaluates the potential maximum exposure in a cloud-free day.

This study demonstrated that the assessment of the exposure to direct sunlight and risk mapping can provide a functional tool to the transportation planners and developers, able to support decision-making process and enhance road network planning. The identification of road segments that are under high risk is very useful information in order to take appropriate decisions and acts to prevent road accidents. Such acts could be the creation of visual barriers in high-risk areas (e.g. row of trees), the placement of warning signs or even the provision of such data to car navigation systems companies in order to provide additional information to the drivers.

In future work, GIS technology could be used in cooperation with Global Positioning System (GPS), for the development of an automated real-time warning system on the detection of high risk conditions in terms of extreme exposure to direct sunlight.

Disclosure statement

No potential conflict of interest was reported by the authors.

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