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DIGITAL ROAD PROFILE USING KINEMATIC GPS

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ABSTRACT. A Digital Road Profile (DRP) is a digital representation of road surface topography or terrain in the longitudinal direction. The need for accurate DRP is vital in two stages; before the road construction starts and after the road construction finished where the verification of its geometrical characteristics is essential for engineering safety purposes. Classical surveying techniques are traditionally used for the DRP generation with limitation of high-cost and time-waste. Kinematic DGPS or Real Time Kinematic DGPS positioning can provide accurate enough results for such application. This paper presents an assessment study of using kinematic GPS technique for DRP generation comparing with classical survey in south Egypt. The results shows that, vehicle-GPS system used in combination with post processing kinematic DGPS gave satisfactory accuracy for nearly all points for a distance of nearly 2 km. with max. and min. difference not more than 7.7 cm, a mean value of 0.10 cm and a Root Mean Square RMS value of 4.11 cm.

Keywords: 1. Digital Road Profile 2. Kinematic 3.GPS

1. INTRODUCTION

Profile is the representation of something in outline. When applied to roads, this means that a profile is a longitudinal-section view of the earth along the centerline, and it is always viewed perpendicular to the centerline. A Digital Road Profile (DRP) is a digital representation of road surface topography or terrain in the longitudinal direction. Accurate DRP is needed before the road construction starts and after the road construction finished where the verification of its geometrical characteristics is essential for engineering safety purposes. This subject has to do with the compliance of the construction to the design data and is very important for the safety of all the vehicles using the road.

Classical survey techniques are traditionally used for RDP generation with limitation factors such as high cost and time-waste. Unfortunately, due to the high cost of data collection with the above mentioned method, the control of the new road can never be complete. The problem becomes more urgent when many kilometers of newly constructed roads have to be quickly checked for geometrical accuracy and, then, be left to common use.

GPS technology could be utilized effectively in this domain. Using vehicle-based GPS receivers for mapping a road network is a common task in many applications, such as mobile mapping (El-Sheimy, 2001), map matching (Taylor & Blewitt, 1999) or real-time mapping (Lakakis, 2000). GPS positional and time data have been used in several occasions for the estimation of traffic conditions along an urban road network (Savvaidis P. et al., 2000). The method usually employed is running along the roads in a vehicle equipped with a GPS receiver. Kinematic DGPS or Real Time Kinematic DGPS positioning can provide accurate enough results in most applications (Zhao, 1997).

This paper presents accuracy assessment study for using kinmetaic GPS for RDP generation for nearly 2 km road length where a GPS system were utilized over a vehicle. The idea for using this scheme was to get the first ideas about its functionality in real conditions and have enough data to study the possible absorption of inclinations from the damping system of the vehicle. In order to test the functionality of the system, classical geodetic methods were used for the accurate measurement of a completed approx. 2 Km road at the Aswan city, Egypt.

2. **MEASURING SYSTEM AND FIELD OBSERVATIONS**

Figure 1 shows the vehicle preparation used for collecting GPS observations along the centerline of 1800 m road length in a rural area of the city of Aswan, Egypt. The RDP was generated using classical survey (TOPCON GTS-712 total station) (Topcon manual, 2000). During this the road was divided into segments with 50 m separation distance, though the number of observed points was 37 points.

The RDP of the road was also generated using post processing DGPS kinematic technique where the baseline length between base station and observed trajectory was between (200-750) m. The system used during GPS collecting observations process was ProMark3 GPS system ProMark3 system is L1 C/A code and carrier with Kinematic Survey Performance

- Horizontal: 0.012 m + 2.5 ppm (0.039 ft + 2.5 ppm)
- Vertical: 0.015 m + 2.5 ppm (0.049 ft + 2.5 ppm)

The average vehicle speed was 18 km/hr with 5 seconds recording interval of GPS observations.

Fig. 1. A picture of the measuring system on the vehicle equipped with GPS system

3. KINEMATIC GPS

Collecting field observations were achieved using PrMark3 single-frequency GPS system whose specifications are shown in table 1. The observations collected from reference and rover points were post-processed using GNSS Solutions software (GNSS Solutions manual, 2007).

Table 1. ProMark3.0 –GPS system specifications (ProMark3.0 manual, 2005)

Parameter	**Specification**
GPS survey mode supported	Static, Stop-and-go, Kinematic
Survey accuracy (RMS) - Static	Horizontal: 0.005m + 1 ppm Vertical: 0.010m + 2 ppm
Survey accuracy (RMS) – Stop-and-go	Horizontal: 0.012m + 2.5 ppm Vertical: 0.015m + 2.5 ppm
Real-Time Performance	SBAS (WAAS/EGNOS) RMS: Horizontal < 1 meter (3 feet) DGPS (Beacon or RTCM) RMS: Horizontal < 1 meter (3 feet)
Survey point spacing – Static (vector length)	Up to 20 kilometers
Survey point spacing – Stop and- go (vector length)	Up to 10 kilometers
Observation time - Static	4 to 40 minutes typical, depending upon vector length
Observation time – Stop-and go	15 seconds typical
Initialization time – Stop-and go	15 seconds on known points 5 minutes on initializer bar
GPS satellite channels	12
SBAS satellite channels	2
GPS satellite elevation mask	10 degrees
Recording interval	1 – 30 seconds

4. STUDY OUTPUTS

Table 2 presents the road height from classical survey and from kinematic GPS. Note that five points were eliminated from the original 37 points for the lake of kinematic GPS derived height. Figure 2 shows Elevation differences between classical surveying measurements and GPS data for the road centerline.

Table 2. The Road Profile height in meters from classical survey and kinematic GPS

Station No.	Accumulated Distance	Total Station Height (m)	Kinematic GPS Height (m)	Height Difference (cm) = Total H-GPS H
1	0	169.838	169.897	-5.8
2	50	170.349	170.362	-1.3
3	150	171.051	171.020	3.0
4	200	171.526	171.449	7.7
5	250	172.247	172.233	1.3
6	400	174.375	174.362	1.3
7	450	175.233	175.238	-0.5
8	500	176.040	176.063	-2.2
9	600	177.354	177.342	1.2
10	650	177.924	177.847	7.6
11	700	178.544	178.502	4.1
12	750	179.032	179.013	1.8
13	800	179.367	179.328	3.8
14	850	179.821	179.795	2.6
15	900	180.662	180.611	5.0
16	950	181.435	181.370	6.4
17	1000	182.199	182.149	4.9
18	1050	182.563	182.560	0.3
19	1100	182.787	182.801	-1.3
20	1150	183.271	183.281	-1.0
21	1200	183.609	183.646	-3.7
22	1250	183.897	183.907	-1.0
23	1300	184.048	184.012	3.5
24	1350	184.334	184.362	-2.7
25	1400	184.398	184.417	-1.9
26	1450	184.467	184.471	-0.3
27	1500	184.507	184.521	-1.3
28	1550	184.600	184.653	-5.3
29	1600	185.257	185.279	-2.1
30	1650	186.157	186.230	-7.3
31	1700	186.396	186.460	-6.3
32	1800	186.043	186.118	-7.4

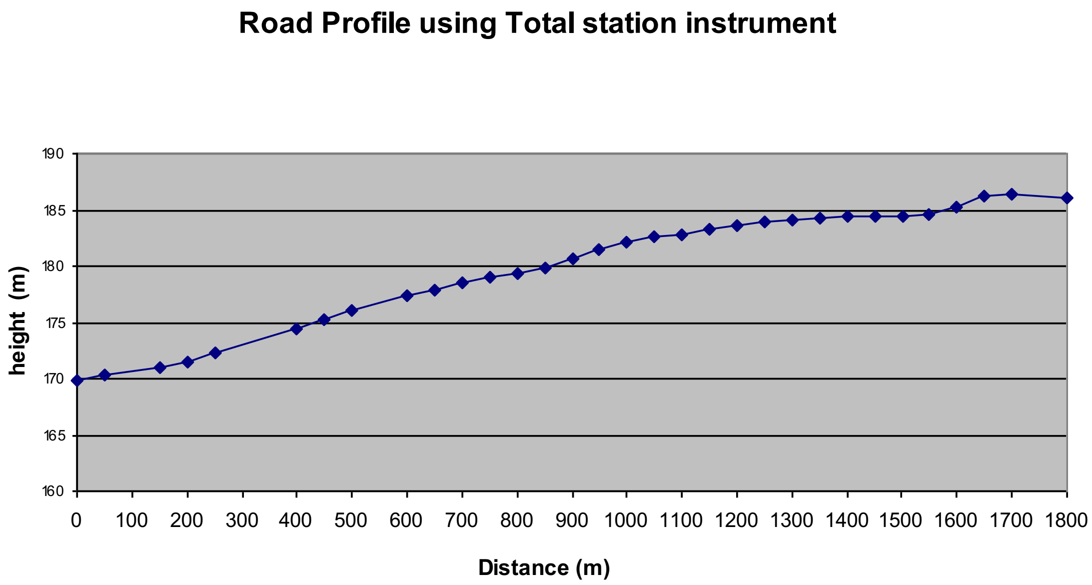

Figure 2. Road Profile using Total Station instrument

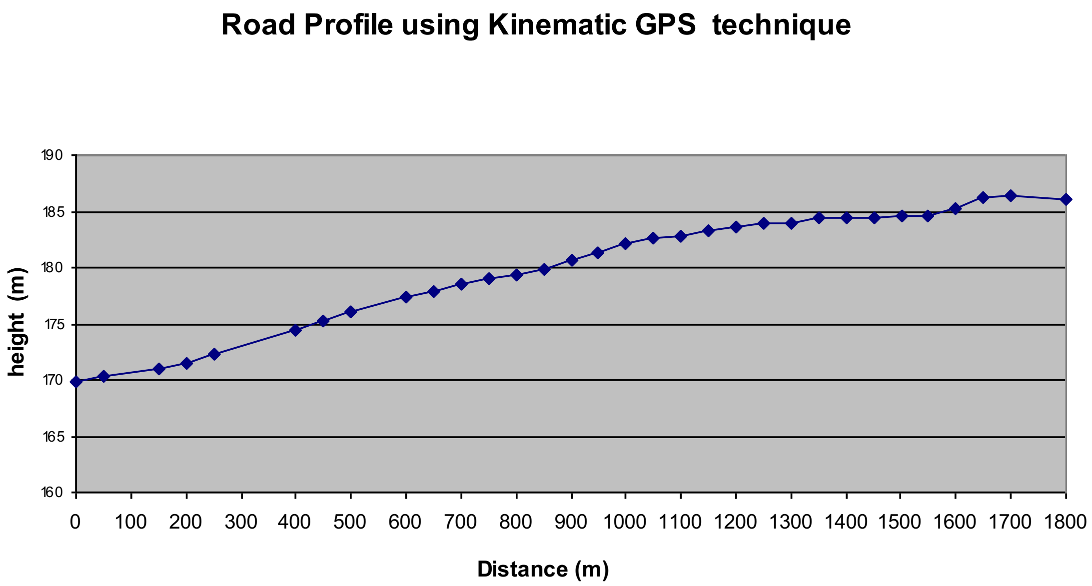

Figure 3. Road Profile using Kinematic GPS technique

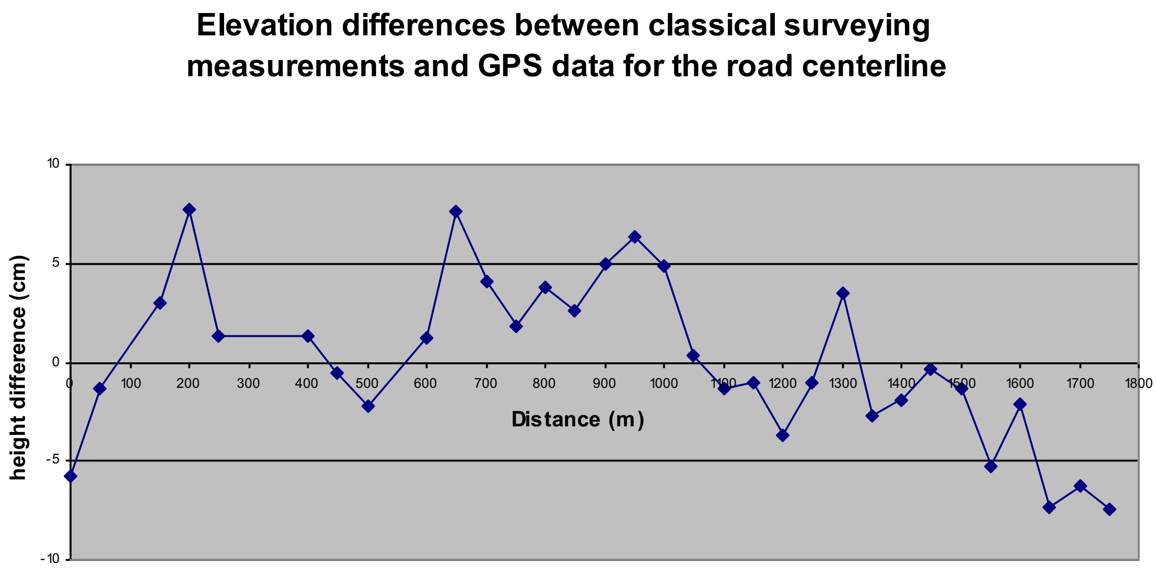

Figure 4. Road Profile-Elevation differences between classical surveying measurements (Total Station) and Kinematic GPS technique

Table 3 presents statistical analysis for the Elevation differences between classical surveying measurements and GPS data for the road centerline.

Table 3. Statistical analysis for the Elevation differences between classical surveying measurements and GPS data for the road centerline.

Parameter	Maximum Height Diff. (cm)	Minimum Height Diff. (cm)	Mean Height Diff. (cm)	Standard Deviation Height Diff. (cm)	RMS Height Diff. (cm)
Value (cm)	7.7	-7.4	0.0969	4.11	4.05

5. CONCLUSIONS

During this research RDP could be generated using vehicle-GPS system with post processing DGPS. The Accuracy of this RDP was tested against classical survey measurements. The following conclusions can be drawn:

1. The computed road profiles from real surveying data and the GPS were in good agreement.
2. The vehicle-GPS system used in combination with post processing kinematic DGPS gave satisfactory accuracy for nearly all points measured with the GPS system.
3. The max. height difference was not more than 7.7 cm with a min. value of 7.4 cm. The standard deviation value of height difference is 4.11 cm. The RMS value for height difference was 4.05 cm with a mean value of less than 0.1 cm.
4. The results obtained from the pilot project show that the vehicle-GPS system can be used for quick road surveying.
5. Future research could be done to improve the system by adding more receivers to test the slope along the road and the super-elevations across the road.

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