

Modeling airborne altimetric LiDAR system to simulate data capture process

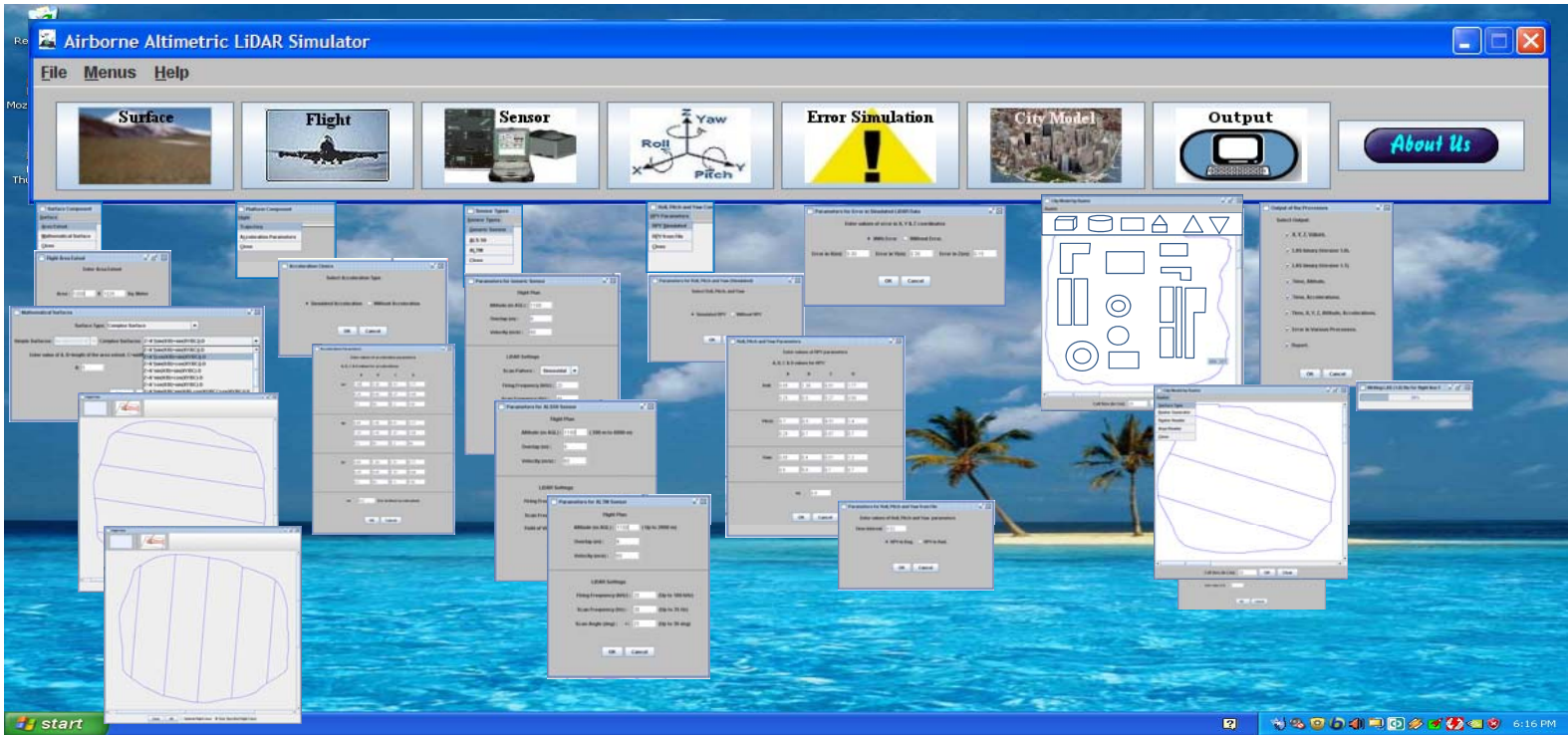
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ABSTRACT

The objective of the simulator is to replicate LiDAR sensor functioning so that LiDAR data can be generated for a user specified terrain with given parameters of the sensor and aerial platform. The simulator is conceived with three components: 1) Terrain component, 2) Sensor component, and 3) Platform component. The terrain component is formed using multiple mathematical surfaces for bald terrain and for objects on top of the surface. Further, the terrain can be represented using a raster. The sensor component permits a user to opt for the commercially available sensors or a generic sensor and accordingly generate data. The third component attempts to replicate the platform parameters, viz. velocity, roll, pitch, yaw and accelerations. LiDAR data are generated by first finding the equation of laser vector that changes with each pulse and then determining the point of intersection of this vector with the mathematical surface or the raster representing terrain. This GUI based simulator, developed using JAVA, is an ideal tool for research and education.



Six degrees of freedom of trajectory

$$d_x^i = \sum_{j=1}^3 A_j \sin(B_j \frac{2\pi}{T}(id, y)) + \sum_{k=1}^3 C_k \cos(D_k \frac{2\pi}{T}(id, y)) + m(id, y)$$

Trajectory coordinates

$$X^{i+1} = X^i + u_x^i d_x + \frac{1}{2} a_x^i d_x^2$$

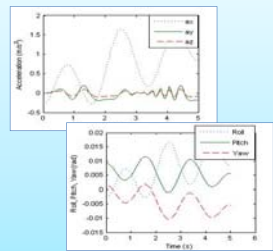
Error introduction

$$X_t^i = X^i + N(\mu_x, \sigma_x^2)$$

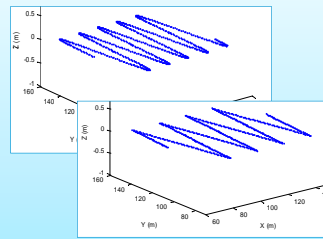
Scan pattern

$$\theta = \frac{\theta_{max}}{P} i \quad \theta = \theta_{max} \sin(\frac{\pi}{2} t_i)$$

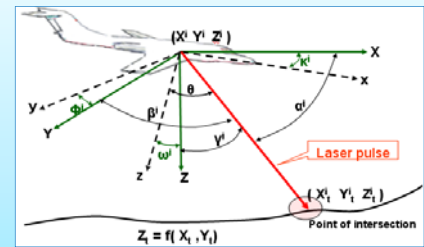
For zig zag where $t_i = \frac{T}{P} i$ For sinusoidal



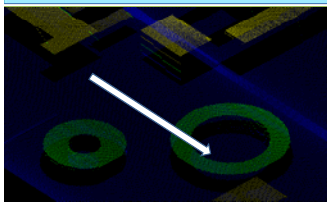
Acceleration and attitude simulation



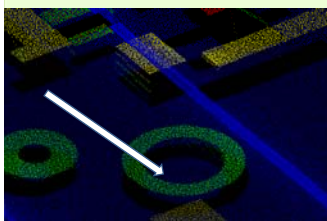
Scan pattern simulation



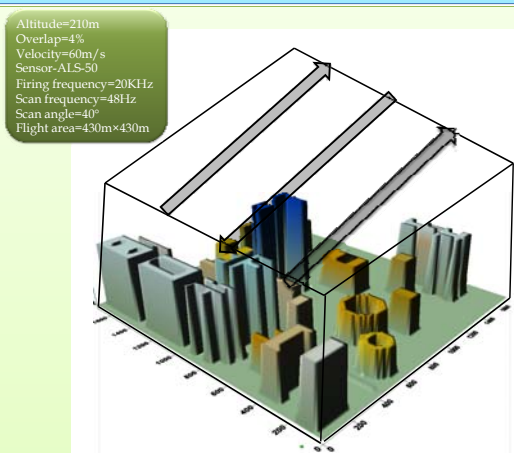
Laser vector intersection



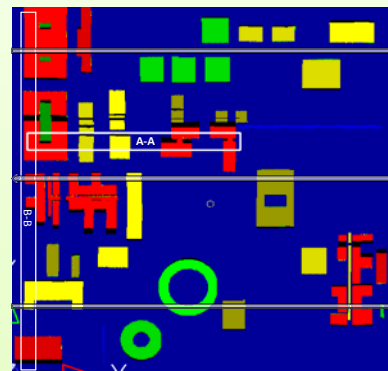
LiDAR data without error



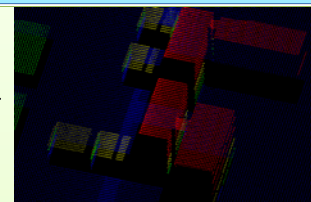
LiDAR data with error



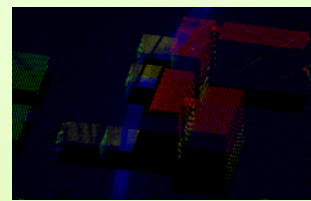
Sample 3D terrain used for simulation



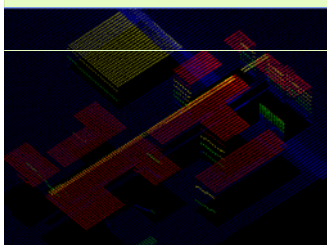
LiDAR data plot in plan



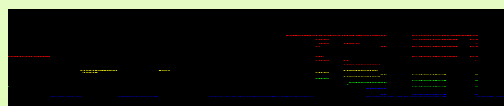
Point distribution over a complex building



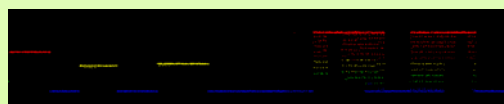
Effect of high altitude



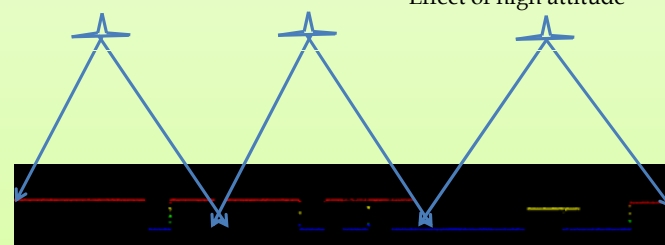
LiDAR points on the walls w.r.t. flight lines



Profile A-A without error



Profile A-A with error



Profile B-B w.r.t. flight lines