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DOE OTD RTDP
Underground Storage Tanks-East
Waste Retrieval System

Long Range Position and Orientation Tracking System

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ABSTRACT

1. INTRODUCTION

The long range position and orientation tracking system (LRPOTS) will consist of two measurement pods, a VME-based computer system, and a detector array. The system is used to measure the position and orientation of a target that may be attached to a robotic arm, teleoperated manipulator, or autonomous vehicle. The pods have been designed to be mount in the man-ways of the domes of the Fernald K-65 waste silos.[1] Each pod has two laser scanner subsystems as well as lights and camera systems. One of the laser scanners will be oriented to scan in the pan direction, the other in the tilt direction. As the lasers scan across the detector array, the angles of incidence with each detector are recorded. Combining measurements from each of the four lasers yields sufficient data for a closed-form solution of the transform describing the location and orientation of the Content Mobilization System (CMS). Redundant detectors will be placed on the CMS to accommodate occlusions, to provide improved measurement accuracy, and to determine the CMS orientation.

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2. DESCRIPTION OF THE ACTUAL WORK

The laser scanner sweeps a three-dimensional wedge that is 45° by 90°.[2,3,4,5] The combined pan and tilt laser scanner wedges are shown in Fig. 1. To determine a detector's pan-and-tilt angle from the laser scanners, the detector must be hit by the laser scanners. This requires the detector to be within the 45° by 45° work area depicted in Fig. 2. At 15.24 m (50 ft.) the work area will have a planer size of 12.62 m (41.4 ft.) by 12.62 m (41.4 ft.). The pan-and-tilt motion controllers on the pod will be used in conjunction with the data from the scanning system to keep the CMS centered in user definable region of interest with the 45° by 45° work area.

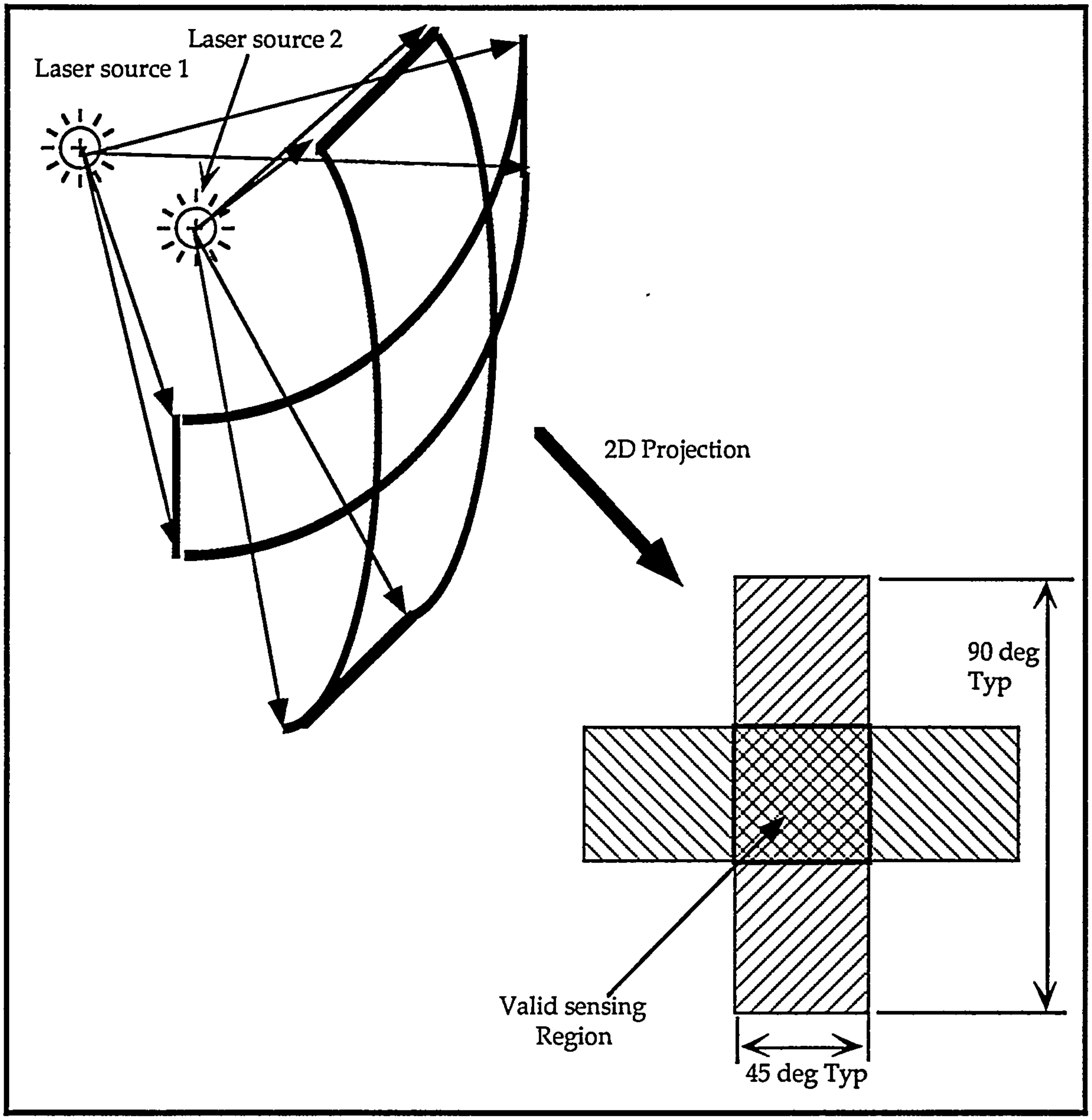
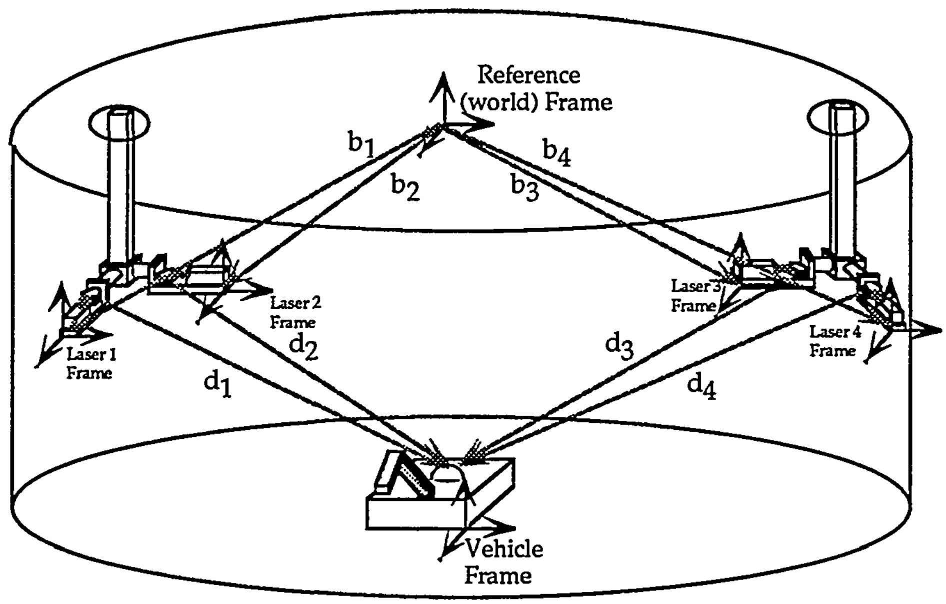


Fig. 1 Pan-and-tilt laser scanners work area.

On the basis of on quaternion algebra,[6] the orientation of the vehicle frame of reference with respect to the world frame can be determined by solving a low-order eigenvalue problem. The data requirements to this algorithm are simply the sensor locations with respect to the vehicle frame and the measured sensor location with respect to the world frame. Occlusion of the sensors can readily be handled by this algorithm. The advantage of this type of formulation over other methods is that this scheme is numerically robust to sensor noise and at the same time has low computational requirements. The orientation algorithm determines the positions of the detectors on the vehicle by analyzing the vector addition problem geometrically depicted in Fig. 2.



Relationship between reference frame, vehicles, and lasers

Fig. 2 Vector analysis of detector location.

3. RESULTS

The system is currently being calibrated. During the sensitivty analysis the pitch and tilt of the line laser relative to the scanning mirrors was found to be the most sensitive variable in the system model. This is being resolved by purchasing lasers that have their optical and mechanical axis more carefully aligned, as well as purchasing mechanical alignment pitch and tilt stages to retrofit into the scanning stages.

4. REFERENCES

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