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14. ABSTRACT
In this report, we describe an experimental test bed we constructed with a variety of sensor modalities for data generation and model validation.
Computer generated 3D target models are now routinely used in graphics and computer aided design, and increasingly in computer vision and image processing. This test bed serves primarily three purposes,

- Data generation of targets for modeling and analysis
- Emulation of realistic scenarios,
- Algorithm verification and validation

the dissertation thesis the grant has funded together with a list

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Infrastructure for 3D imaging Test Bed (FA9550-06-1-0316)

Problem studied

Computer generated 3D target models are now routinely used in graphics and computer aided design, and increasingly in computer vision and image processing. This test bed serves primarily three purposes,

- Data generation of targets for modeling and analysis
- Emulation of realistic scenarios,
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Introduction

The current experimental test bed described here and partially funded by AFOSR DURIP grant FA9550-06-1-0316 is a collaborative effort with Dr. Helena Mitasova from the Dept. of Earth and Atmospheric Sciences supplementally funded by an ARO DURIP grant. We have joined our resources to equip a laboratory with a sufficient number of modalities for 2D and 3D target measurements as well as geospatial data measurement and processing.
The sensing technologies include 3D laser scanners, optical, infrared and thermal cameras, network video cameras, multispectral camera and time of flight camera, as well as a constructed structured light 3D camera and high performance graphic workstations. This joint effort is reflected by the shared research interest in 3D modeling with direct applications and benefit to DOD (target modeling in virtual (realistic) battlefield theater of specific topography and target classification/recognition in surveillance applications). In particular, we have measured numerous mock models of planes, tanks and utility military vehicles using a laser ranger for 3D pictures, infrared and multispectral for 2D images. Terrain models were measured and water flows were emulated and projected on terrain models. Almost any theater scenario may now be emulated in the laboratory with measurements corresponding to application algorithms. We note that our sensor infrastructure has provided us with a special opportunity to investigate other problems such as *remote biometrics* which have recently emerged as an important research priority for the Air Force.
We include in this report a detailed account of all purchased equipment as well as illustrative measurements which we are able to make and how are leveraging the experimental test bed in pursuing our research. The report is organized as follows: section 1 list all the equipments, section 2 we describe which experiment we have conducted so far, and at the last section we conclude with some future work.

1. Equipments

With the support of AFOSR, the VISSTA laboratory is now equipped with the following sensor modalities and data acquisition systems.

ITEM	VENDOR	PRICE
VRMesh Education 3.0 software	VirtualGrid Company	$295.00
Soviet battle tank; Osprey Helicopter	Oakridge Hobbies & Toys	$81.43
EDU Complete SStudio; Education Complete – Qualify Node	Geomagic	$500.00
Hydrostatic Ball Head	B&H Photo Video	$338.80
2 Duo Processor E6400 Computer system	Dell Marketing, L.P.	$1,173.84
Military Model	CrossroadsDiecast.com	$69.95
Military Models	CrossroadsDiecast.com	$211.80
Canon Powershot camera	CDG-G	$407.98
EDU Complete SStudio; Education Complete – Qualify Node	Geomagic	$500.00
Telephoto lens for camera	Amazon.com	$179.90
Cine-video Jib & accessories	EZFX, Inc.	$1,857.00
Bogen ball leveler	Adorama	$49.60
3-D Scanner	Konica Minolta	$14,990.59
Time-of-Flight Camera	CSEM	$6,895.00
PS Remote software	RegSoft.com	$49.00
Military models	CrossroadsDiecast.com	$87.89
Lens Holder and tissue	Edmund Optics	$118.45
Optics equipment	Newport Corp.	$54.08
PST Softbox Kits, Background stand & paper	Adorama	$586.20
Spatial Light Modulator	HOLOEYE Corp.	$4,500.00
Thermal Infrared Camera	Sierra Pacific Innovations Corp.	$4,495.00
Optics equipment	Newport Stratford	$962.68
2x Samsung SDN-550N camera	2MCCTV	$728.98
Osprey video capture card	PC Mall	$144.70
Power outlet accessories	CDW-G	$46.88
Multispectral Imaging System	Channel Systems	$10,176.50
Magellan Desktop Turntable	Kaidan, Inc.	$1,358.48
Power accessories	Cables N Mor	$22.69
TOTAL		$50,882.42

Fig. 1-4 show the running equipments.

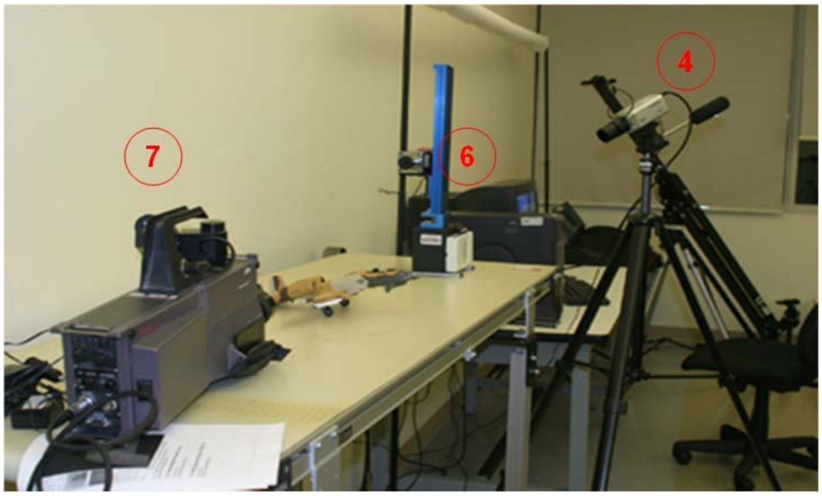


Fig. 1: 2D cameras (4, 6, 7)


Fig. 2: 3D laser scanner (1)

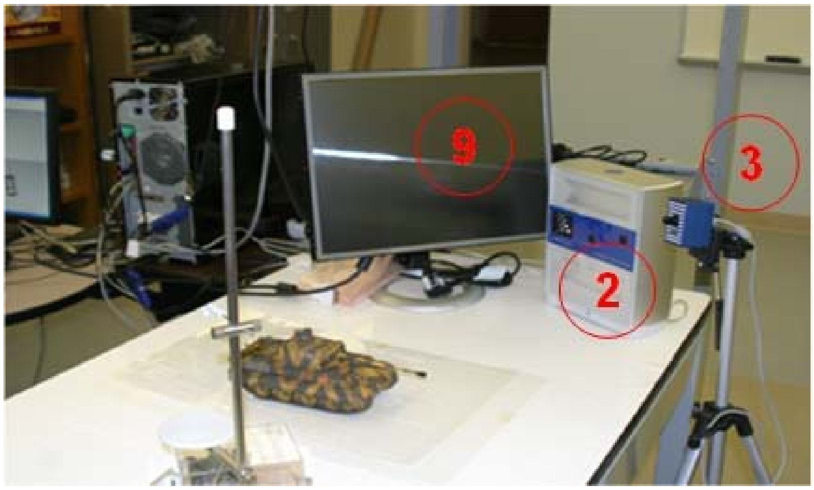


Fig. 3: 3D equipments (2, 3, 9)


Fig 4: A network video camera (5)

2. Experiments Conducted

Using the acquired modalities, we are essentially able to capture different characteristics of objects, for example, shape, light reflection, temperature, motion and others. Amonf the experiments thus far conducted include,

(a.) 3D target models in ATR: Laser scans of tanks, airplanes, and trucks result in point clouds which are subsequently triangle-meshed by Geo-Magic software to construct full 3D models.

(b.) 3D models of skulls for Forensics: A laser scan of real human skulls also morphed into a triangular mesh for further analysis.

(c.) Real time detection & analysis of human gait: using a video camera we capture walking human silhouette for pattern modeling and gait analysis.

Fig. 5 shows the scanning result result that is fed into a Geo-magic software tool for 3D meshing.

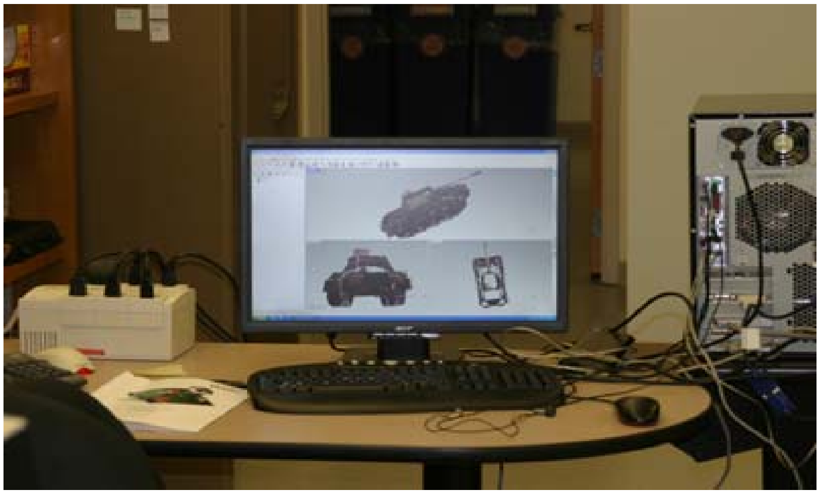


Fig. 5: 3D scanning result

In addition to the above experiments, we are able to also collect data of different nature or spectral characteristics. Fig. 6 shows the data acquired from a multispectral camera.

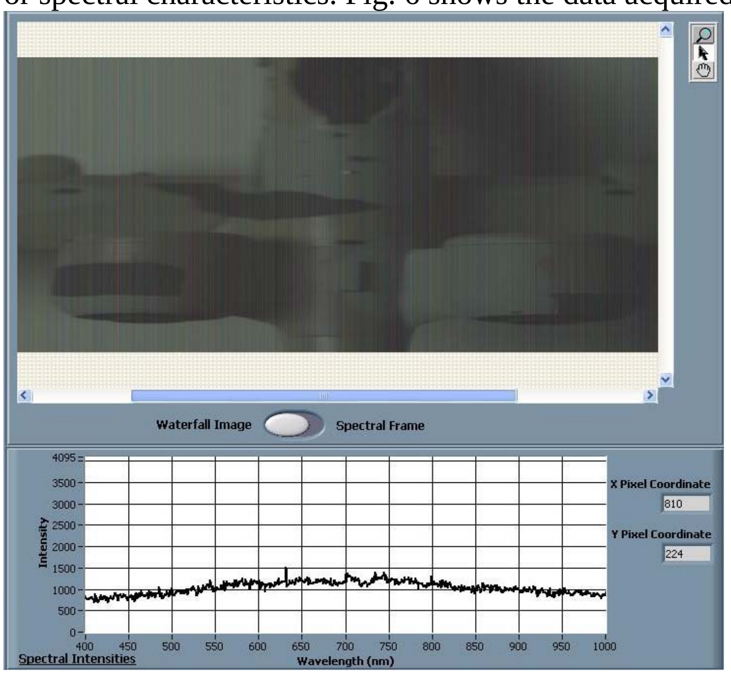
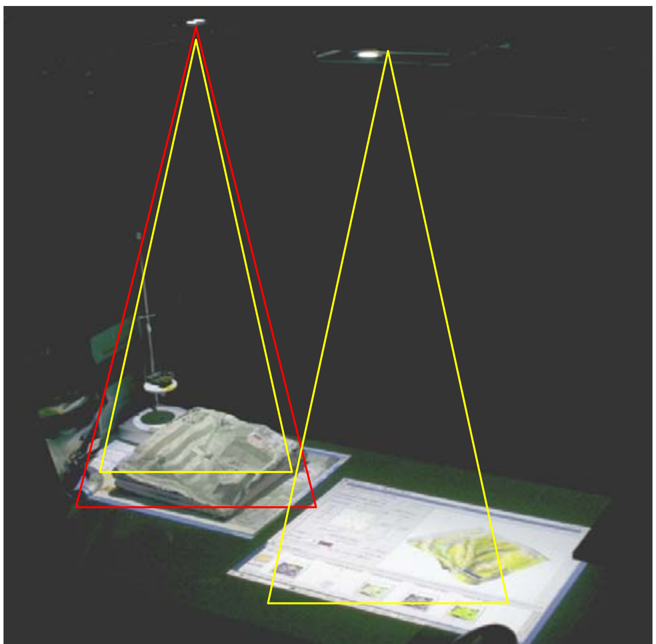


Fig. 6: Multispectral camera scan of an airplane.

Our collaborative effort with Dr. Mitasova, is of central importance to our overall objective of 3D imaging for surveillance and ATR applications. A Tangible GIS and geospatial sensor data processing research is performed in collaboration with the Remote sensing Group of Dr. H. Mitasova, Department of Earth and Atmospheric Sciences.

To briefly describe the terrain modeling activity, we construct the Tangible GIS system using a 3D laser scanner Minolta VIVID-910 which captures surface geometry of a physical clay model representing a studied landscape. The scanning output is transformed into the Digital Elevation Models (DEMs) using a computer workstation that controls the scanner and generates images for a projector that is coupled with the 3D scanner and projects the images onto the landscape model. Terrain analysis algorithms are applied to the DEM and results are projected back on the landscape model. The scanner/projector pair is placed on a shelf approximately 1.5 m above the tabletop workspace that includes the physical model. Additional projector and a 3D display are coupled with the system for creating a virtual terrain model and 2D section of the tabletop workspace with GIS subsystem interface (Figure 1). A 3D Phillips display allows users to experience simulated 3D objects without the aid of special glasses. The display projects two different images to the viewer’s eyes, each image a different perspective of a 3D scene. Under this condition, the viewer’s mind can perceive the scene in three dimensions slightly extruding from the display screen. The 3D scanning system has been further enhanced by adding a low cost, desktop scanner that is used to scan models of structures and other smaller objects as well as for simultaneous nadir and side scanning of the landscape models needed for capturing the vertical sides of structures placed on the landscape.



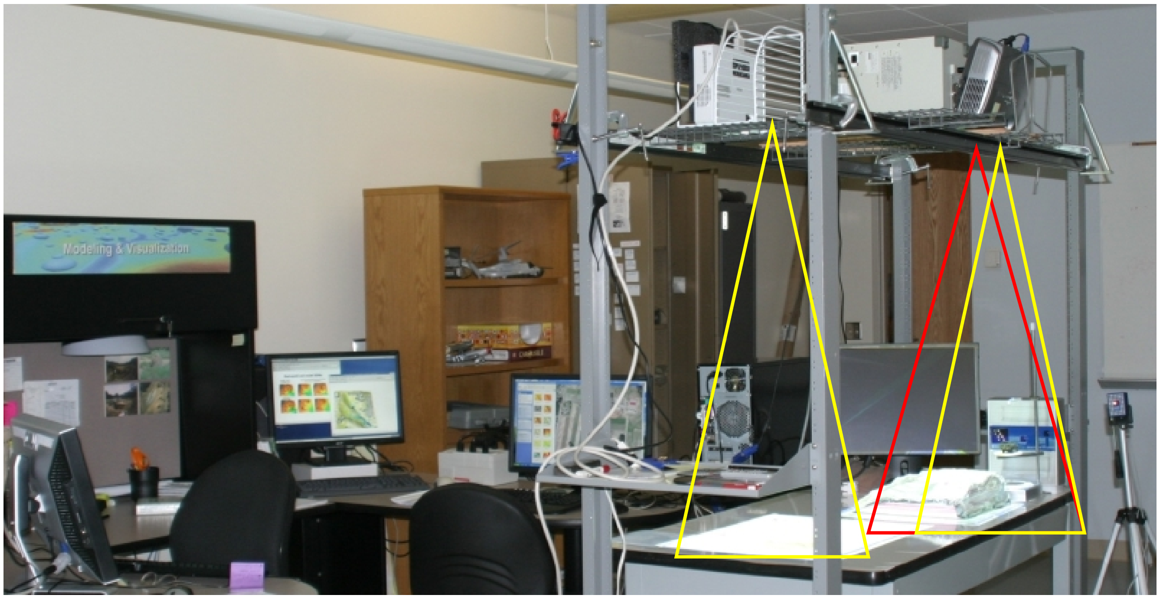


Figure 7. System in action: 3D clay model is scanned (red), existing GIS data, results of topographic analysis or animated flow simulation are projected over the surface (yellow)

The system setup employs a bridge with easy to modify shelving used to mount the scanner, projectors and or additional sensors/cameras, making the system very flexible (Figure 1). It allows us to experiment with various configurations while we evaluate different combinations of devices for different types of applications. The fixed mode keeps the model surface static while images and animations created from GIS data are projected over the surface (e.g., to provide information about the land cover to guide the design). The flexible configuration allows the user to modify the terrain surface while it is scanned and the selected terrain parameter or process simulation is re-computed and projected over the modified surface. The topographic parameters included slope, aspect, curvatures, flow pattern, elevation difference, profiles, and visibility.

Multiple scenarios of landscape development with various building configurations (Figure 7) were also created to study their impact on spatial pattern and rate of runoff and erosion (Figures 8 and 9).

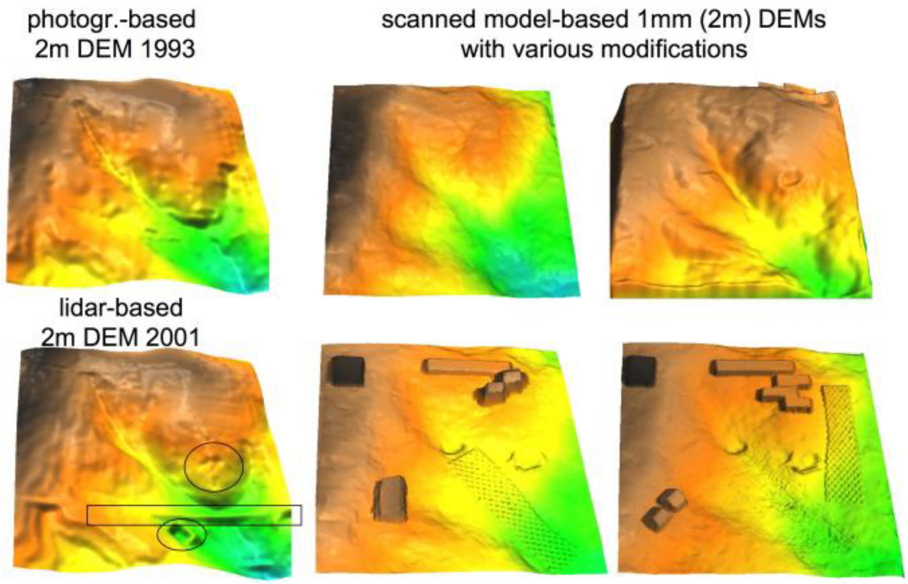


Figure 8. Experiments with different landscape modifications

We have endowed our laboratory with other capabilities in capturing both the model geometry and material properties. These sensors include 3D Swiss Ranger SR-3000 Time of Flight Camera, Samsung Color Video Camera, Channel Systems Multispectral Camera and Infrared Camera. We have also initiated experiments in coupling the system with real-time data by using network cameras (Axis PTZ and StarDot network cameras) to capture the landscape dynamics. Automated recognition of different structures using color coded objects, RGB image scanning capabilities of VIVID 910 and other sensors using image processing tools are also being explored.

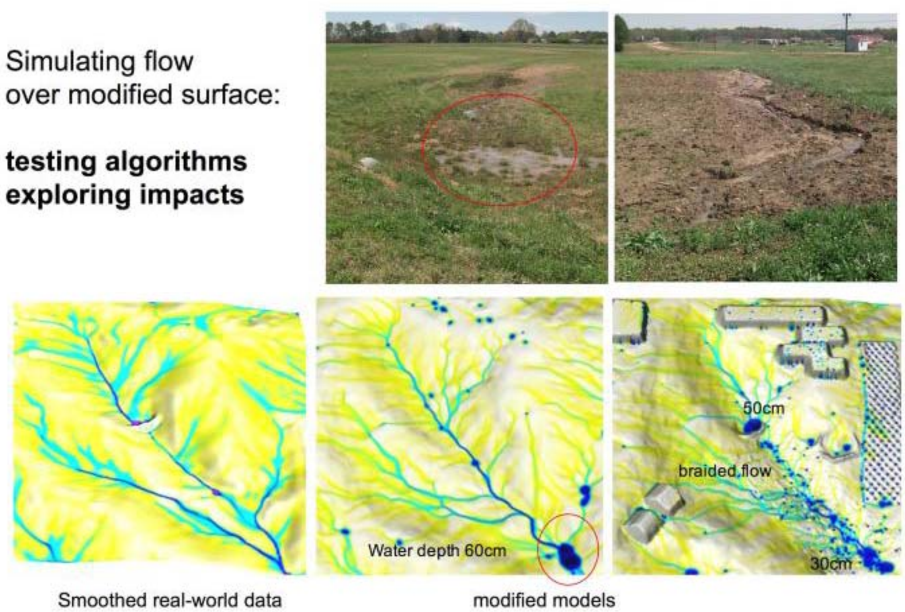


Figure 9. Simulations of overland flow for real-world data and model-based scenari

Related research projects The equipment has enhanced the NCSU projects funded by DoD (specifically our AFOSR grant on Target recognition and ONR on LIDAR modeling) (H. Krim) as well as those that focus on terrain modeling and analysis of topographic change, in particular the ARO staff research project (H. Mitasova)

Research-related education The equipment provided the foundation for establishing new infrastructure for research related education in the area of 3D landscape modeling and analysis as well as 3D modeling in general. The system is being used to explore and develop programs for education at graduate and post-graduate level in geosciences and environmental science at the Department of Marine, Earth and Atmospheric Sciences, in erosion and sediment control at the Department of Soils Science and in 3D point cloud data processing and analysis at the Department of Electrical and Computer Engineering.

Interface with existing facilities Interfacing with existing facilities, specifically the Department of Electrical and Computer Engineering Vision, Information and Statistical Signal Theories and Applications (VISSTA) laboratory ans the Remote Sensing Labarotory led by Dr. H. Mitasova has been very successful and allowed us to significantly expand the experimental environment. For example, the 3D scanners have been used both as a component of Tangible GIS as well as for scanning on vehicle models used for Air Force funded research (Figure 5). The system development has been also coordinated with NCSU computational and monitoring facilities at the Center for High Performance Simulations, Department of Physics, the Soils Science Spatial laboratory and SECREF, and the Kennan Hazard Mapping Laboratory, CCEE.

On the other hand, all sensors in our lab provide us a variety of data in different modalities, which makes it possible for us to answer the question that how the data from different modalities of the same object facilitates ATR.

3. Future work and contribution

With more 3D models captured, we will make a database of 3D military objects available upon request for the research community so that it may help researchers to evaluate their own algorithms more efficiently. Comparison of different ATR algorithms is also possible based on the same data base.