



# Augmented Reality with Learning Agents

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School of Electrical Engineering and Computer Science

**Advanced Simulation Research**

investigates

Decision Support and Design Aids by Merging

Data Acquisition

Computer Vision

Robotics

Computer Animation

Augmented Reality

# Simulation Driven Virtual Objects In Real Scenes



# Outline

- **Background & Research Objectives**
- **Architecture**
  - **Live Images**
  - **Virtual Images**
- **Terrain Correlation**
- **Algorithms for Object Detection and Occlusion**
- **Demo**

# Motivation

- **Embedded Training**
- **Advanced Simulation**
- **Movies and Games**

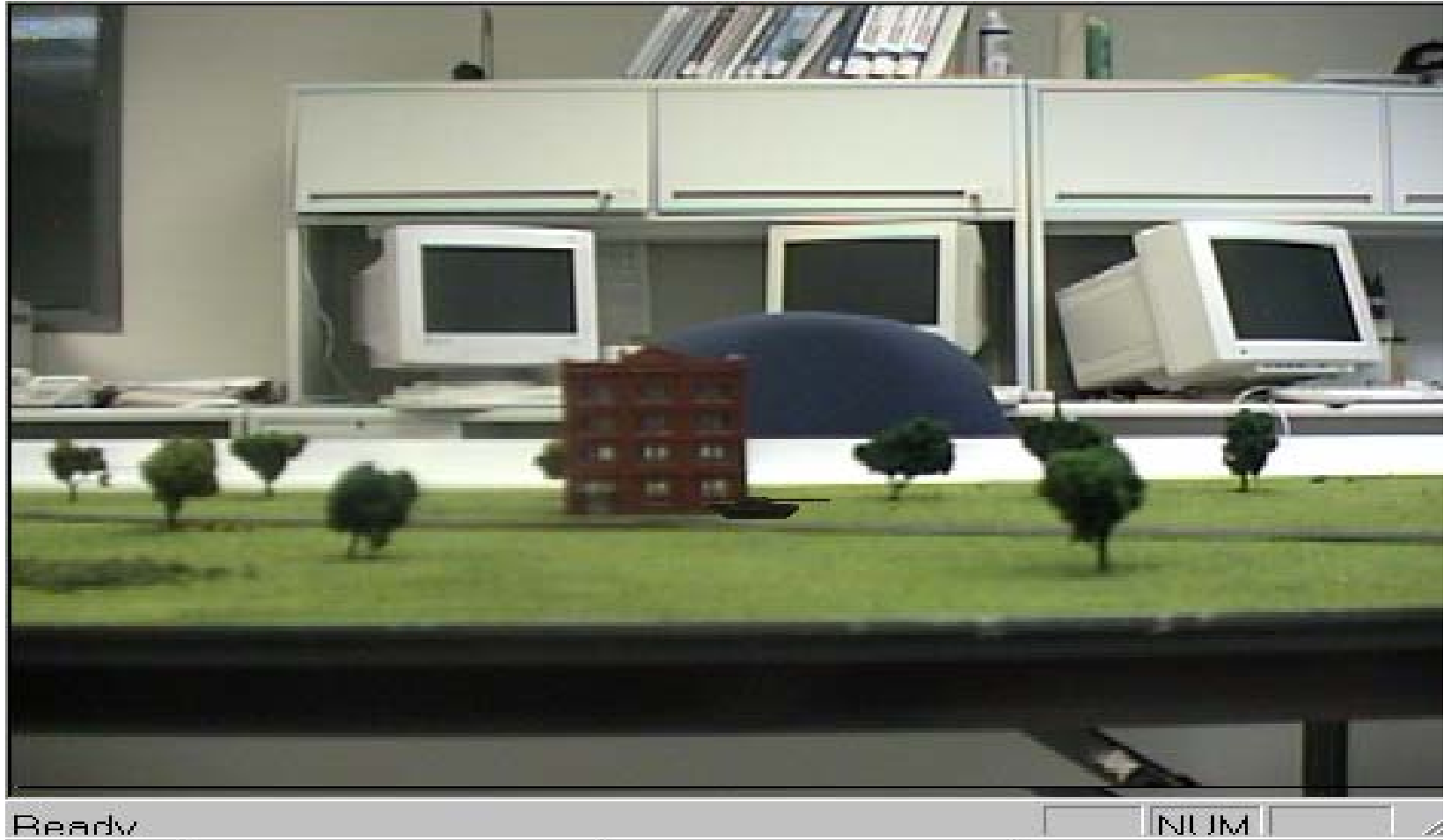
# Application to Military Training

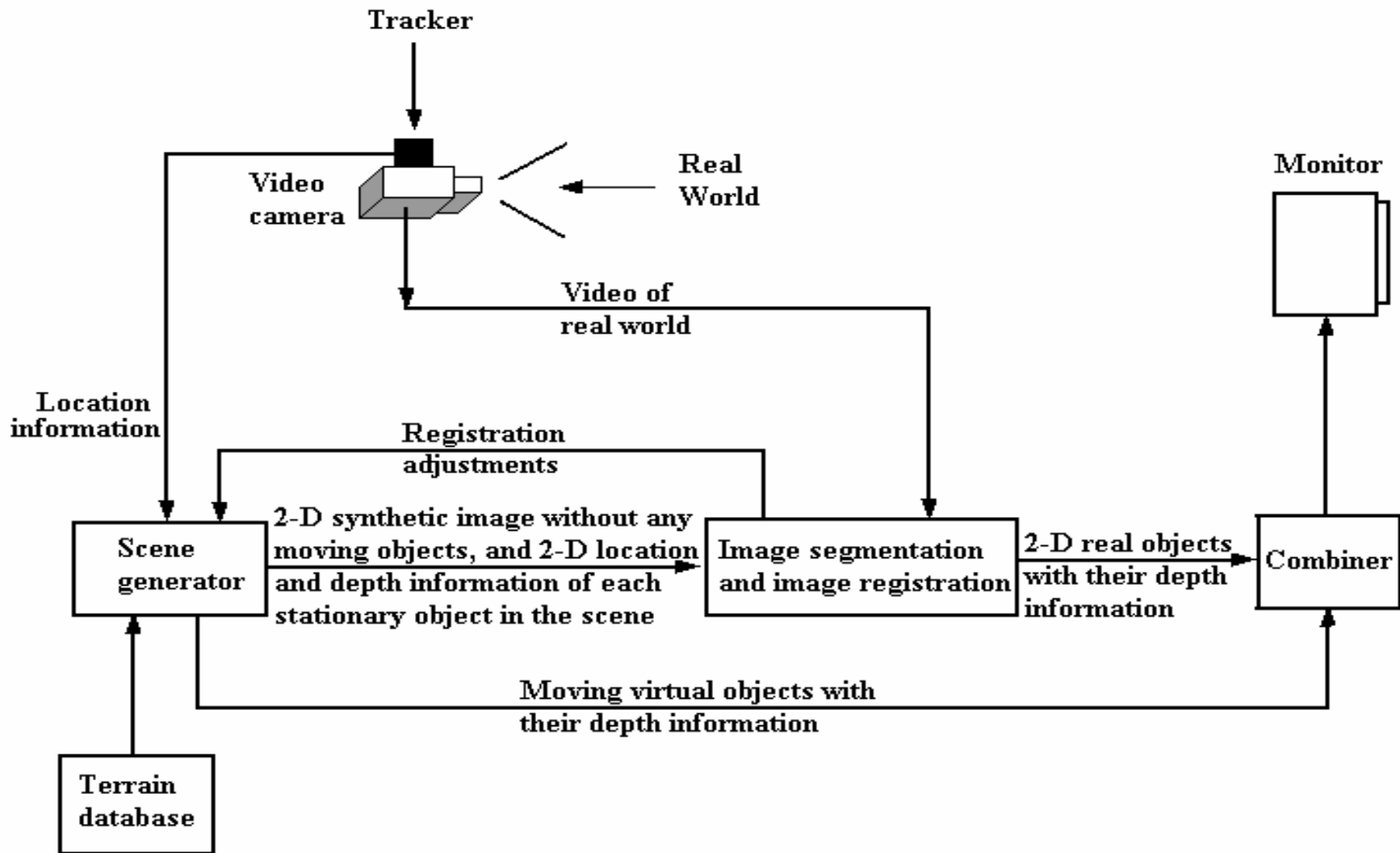
- **Live Training**
- **Realistic but Synthetic Targets**
- **Synthetic Fire & Targets, Lower Cost**

# Research Challenges

- **Realistic moving targets**
- **Proper occlusion**
- **Insertion of synthetic moving objects in live scenes**
- **Moving objects conduct Goal Based automatic mission**

# Real-Time Simulation with Augmented Reality





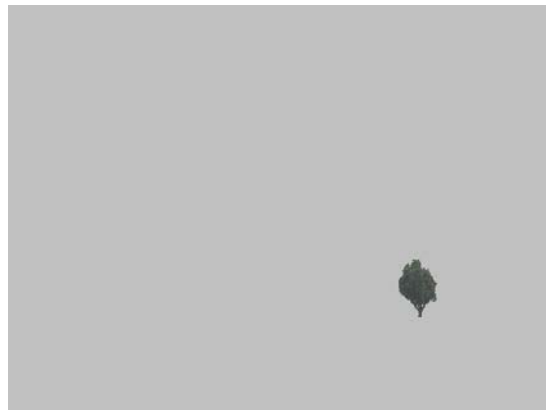
# Live Representation of Terrain

- **Live views as seen from:**
  - Tank Gunner's Primary Site
  - Tank Commander's View
- **Camera formats**
  - FLIR imagery
  - Optical camera

# Live Terrain Image



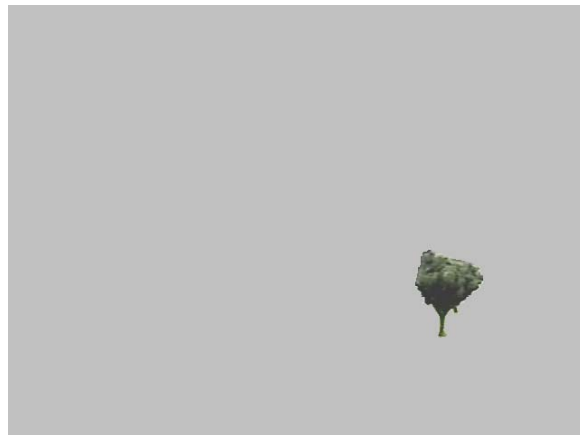
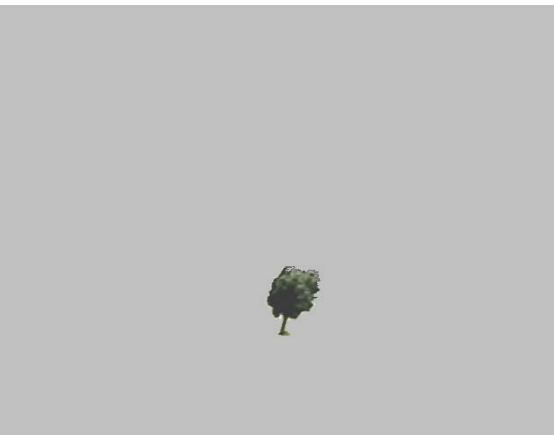
# Synthetic Objects are Generated from Terrain Database



# Synthetic Objects are Used to Locate and Segment Corresponding Real Objects



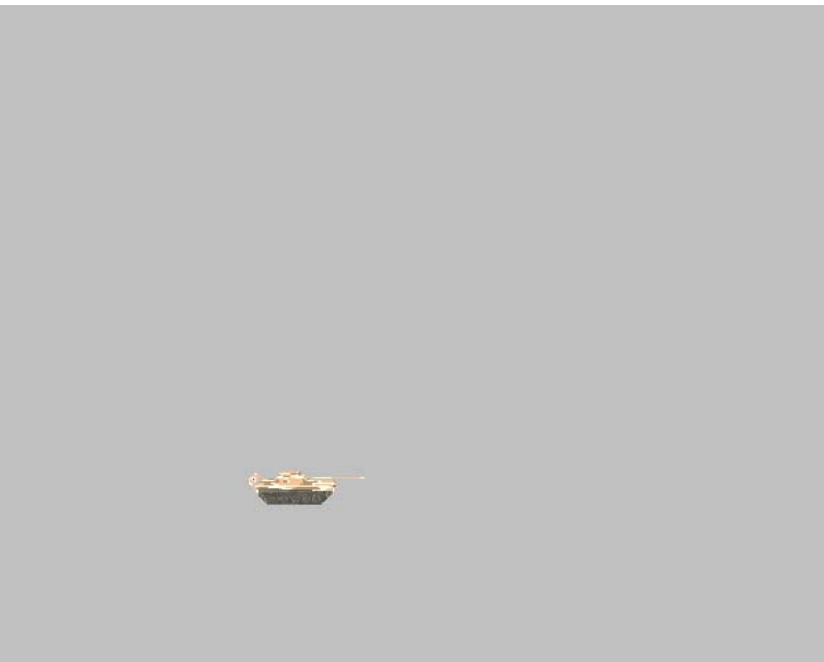
# Once Real Objects are Identified We Decompose the Live Image into Objects



A synthetic moving-object, and its insertion  
into the live scene.

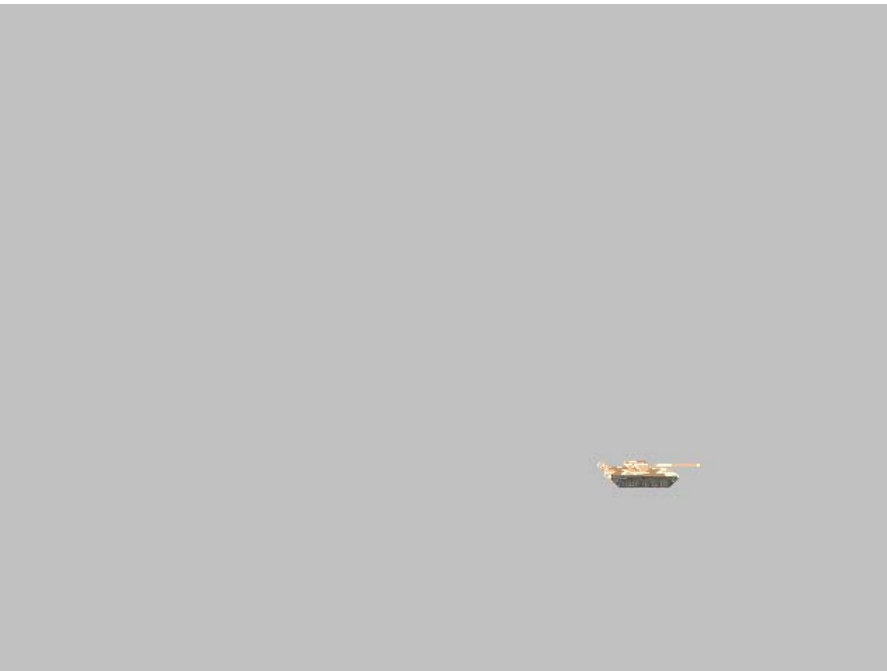


**A synthetic moving-object, and the result of inserting it into the live scene.**





**A synthetic moving-object, and the result of inserting it into the live scene.**



**A synthetic moving-object, and the result of inserting it into the live scene.**

# Virtual Representation of Terrain

- **Polygonal representation for visual accuracy. Used by stealth applications.**
  - **OpenFlight, ...**
- **Topological representation for ease of computation. Used by SAF applications**
  - **CTDB, ...**

# Stealth Applications

- Use video card hardware to render scenes
- Processed internally instead of displayed to the screen.
- Commercial options:
  - X-IG
  - OpenGL
  - Performer perfly

# Virtual Terrain Image



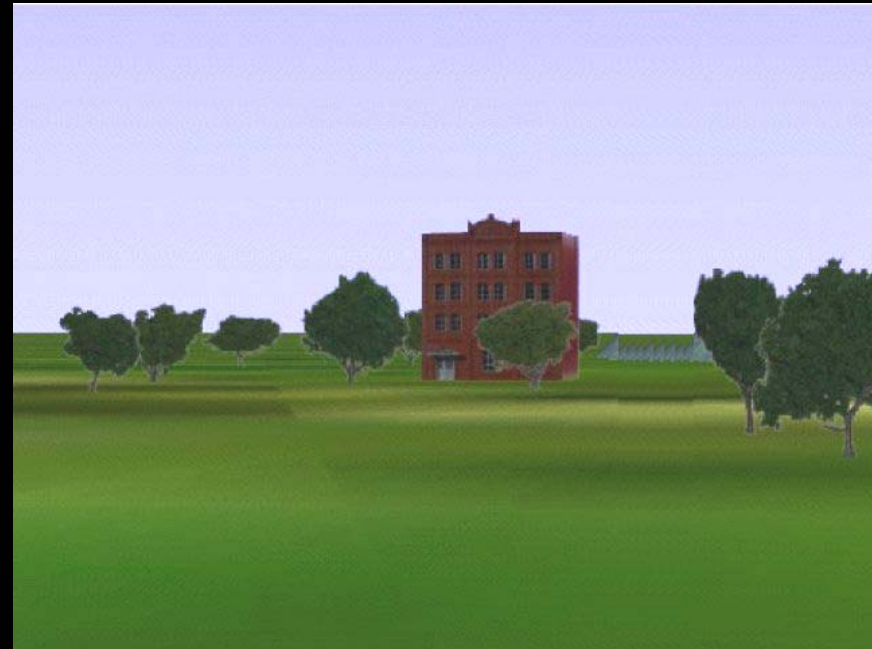
# Optical Camera Information

- **Must correlate the position of virtual terrain view with live camera image**
- **Using camera information to match virtual terrain and live scene**
  - **Position**
  - **Orientation**
  - **Zoom**

# Scaled Synthetic Image



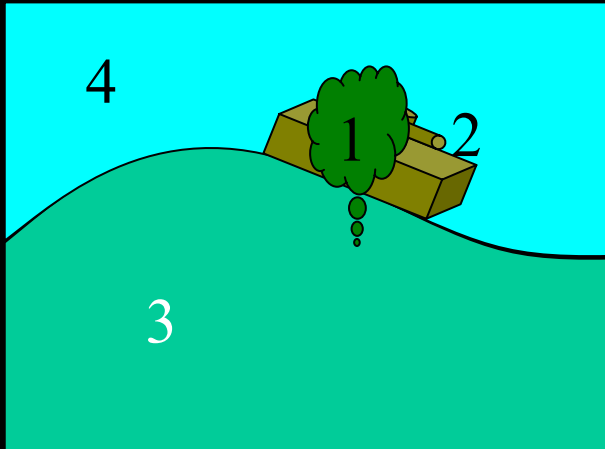
# Tabletop Terrain Correlation



# Error or Difference Image



# Depth Ordering



- **Mark major objects with a relative depth ordering**

# Object Insertion w/Occlusion

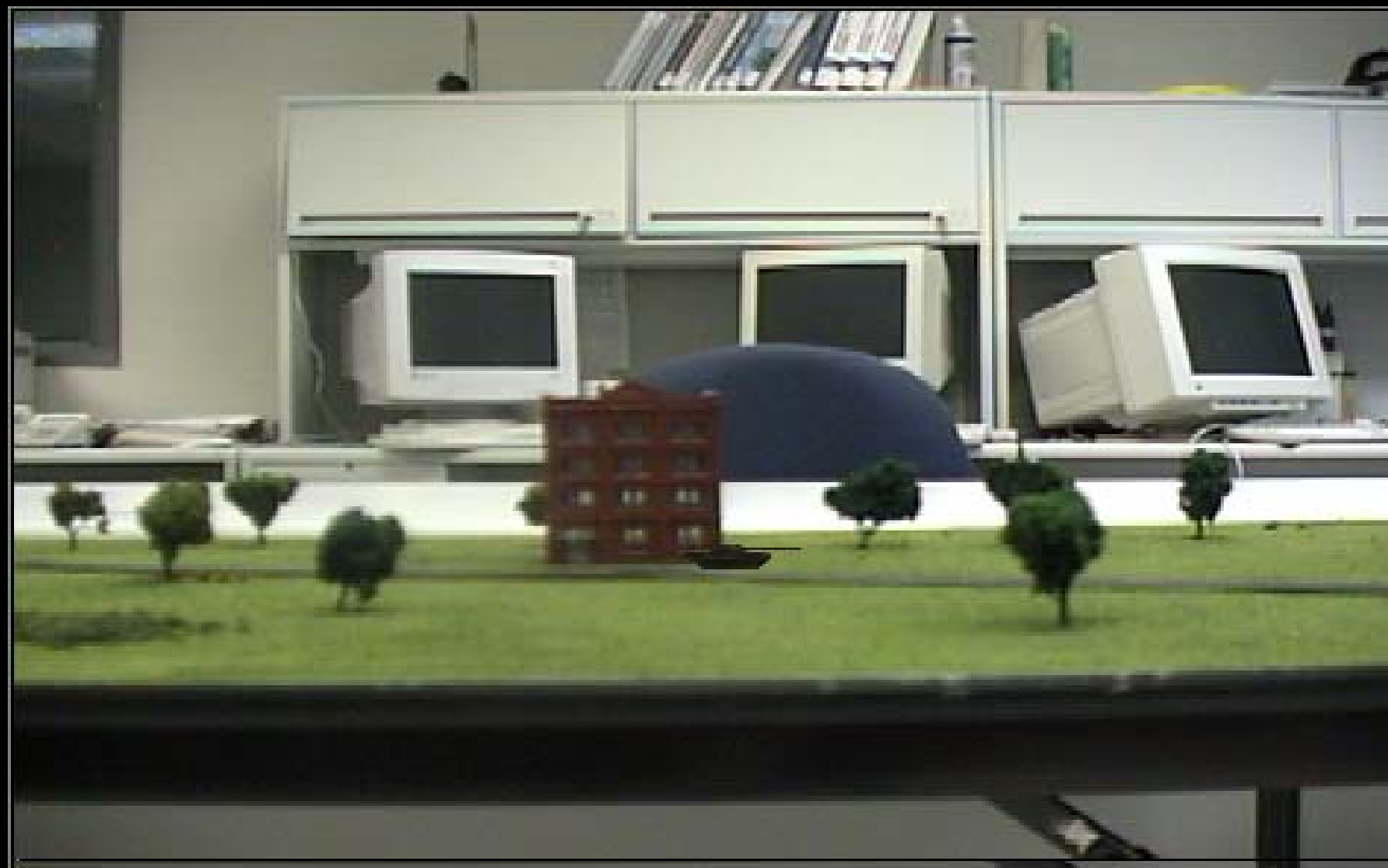


- **Insert object based on the relative depth**
- **Overlaying the live image over parts that should be occluded.**

# Synthetic Image 1



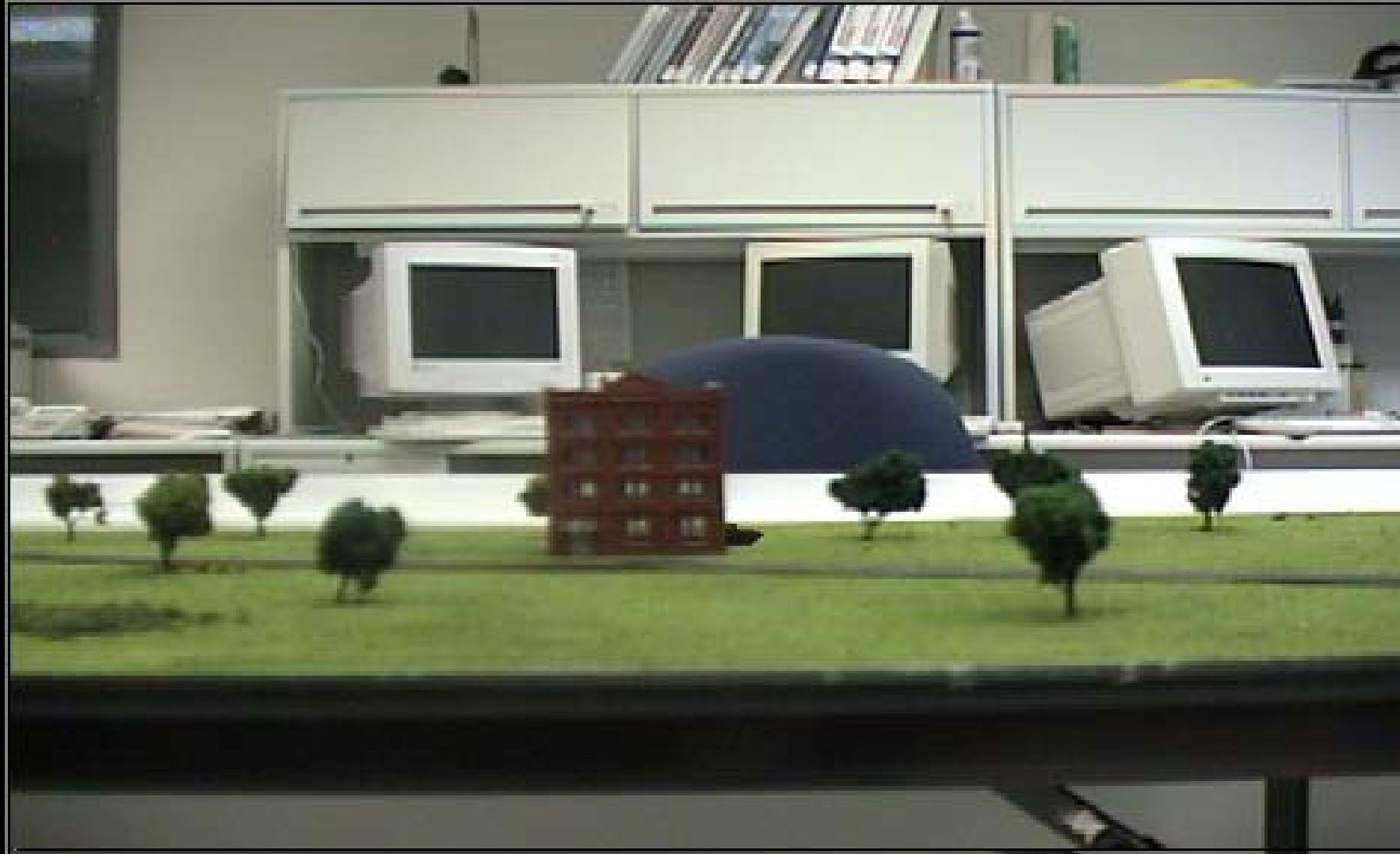
# Real Image 1



# Synthetic Image 2



# Real Image 3



Ready

NUM

# Applications

- **Embedded Training**
- **Target Overlay System**
- **Realistic Games**

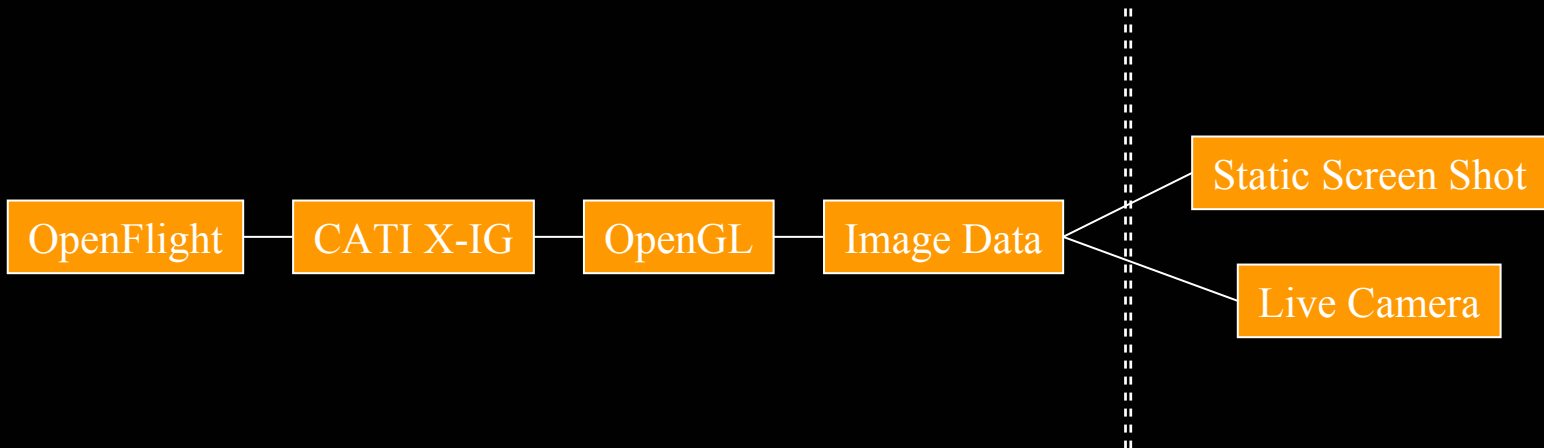
# Defense Purpose

- **Live Training**
- **Realistic Targets**
- **Lower Cost**

# Prototype Architecture

- **Components of the prototype Architecture**

VIRTUAL IMAGE -- Matching Algorithms -- REAL IMAGE



# Open Problems Dealing with Complex Terrains



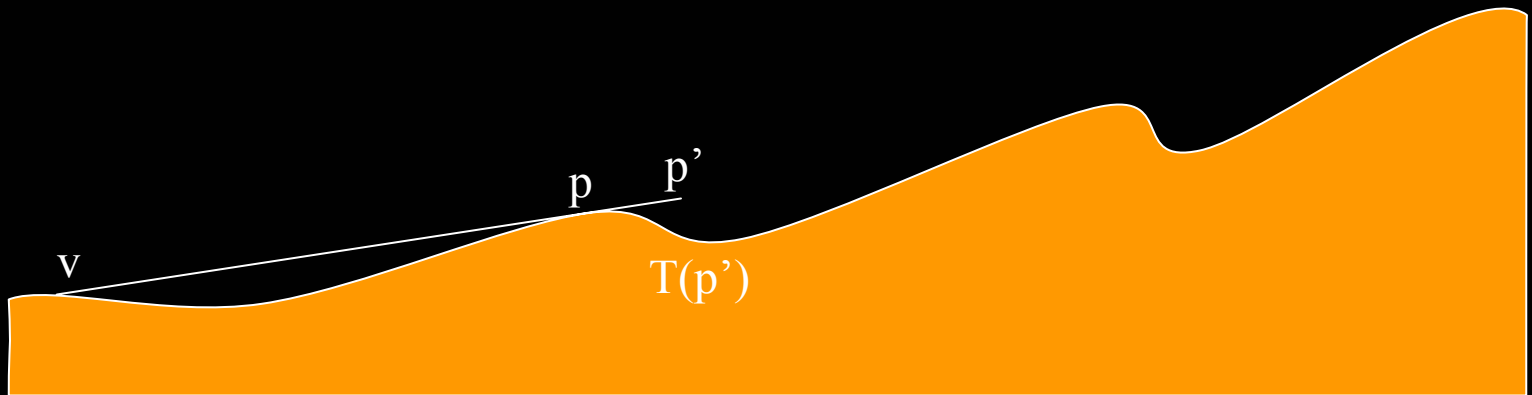
# Research on Ridge Detection Algorithms

- Let  $v$  be the viewpoint, and  $p$  an arbitrary location on the terrain database, both in 3-D  $[x,y,z]$
- Let  $\underline{vp}$  denote the vector from  $v$  to  $p$ .
- Let  $p' = p + \Delta[\underline{vp}]$
- $T(p')$  is the point on the terrain database right “under”  $p'$ :
  - $T_x(p') = p'_x$ ,
  - $T_y(p') = p'_y$  and
  - $T_z(p') < p'_z$  if such a point exists

# Ridge Detection Algorithms

- We will say that  $p$  is a ridge point with respect to viewing point  $v$  iff  $T_z(p') - p'_z > S_c > 0$
- We will say that  $p$  is a ridge point with respect to viewing point  $v$  iff  $Tz(p') - p'_z > S_c > 0$
- Here  $S_c$  is a “critical size” related to the objects being viewed and (to some extent) to the distance  $|vp|$  from  $v$  to  $p$
- In future work this definition will be used to detect ridges and terrain occlusion in the images

# Ridge Detection Algorithms





SEEGS

# Demonstration

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# Acknowledgements

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**SEECs**