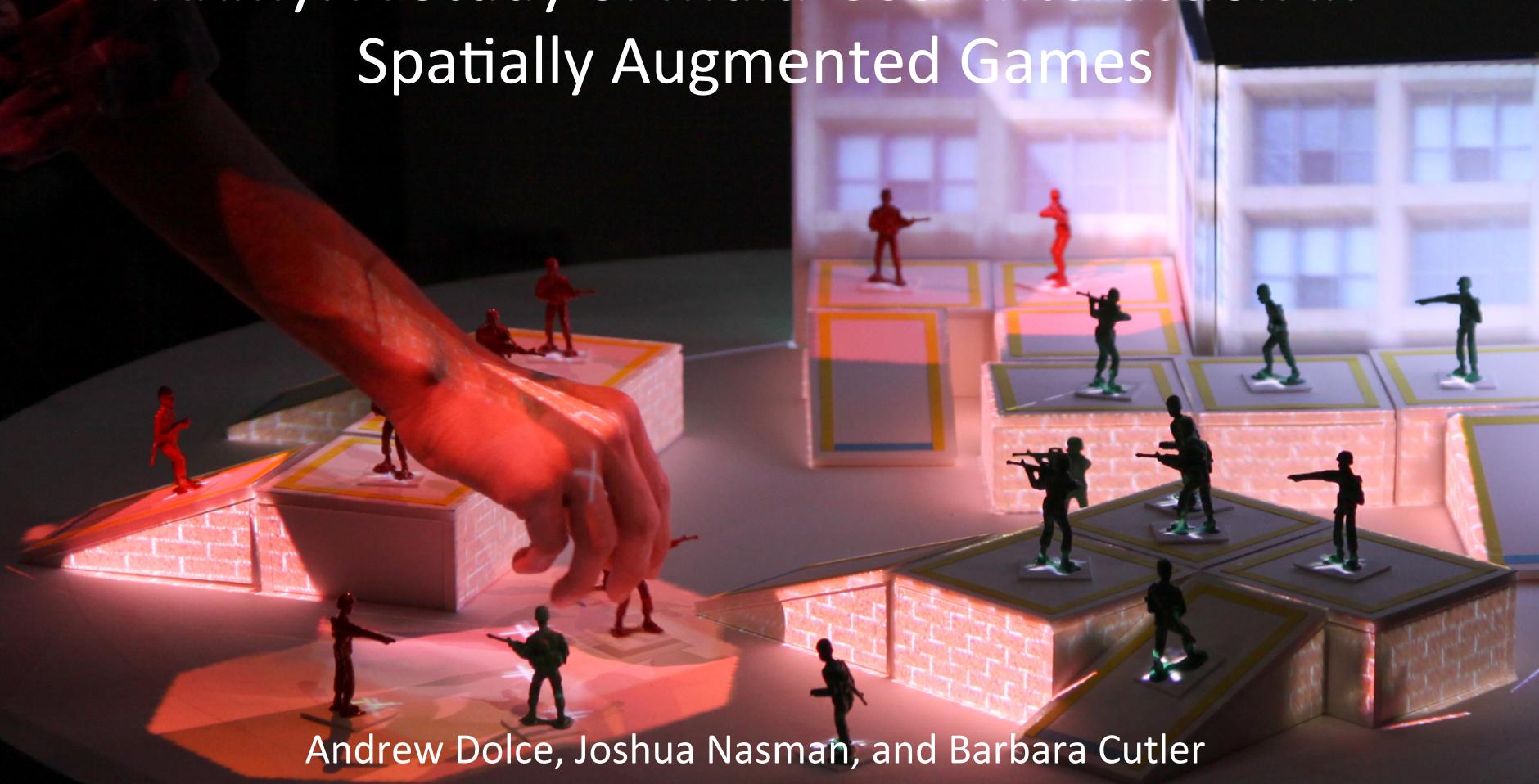


ARmy: A Study of Multi-User Interaction in Spatially Augmented Games



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Video Games

- Interactive
- Simulative
- Immersive

Controls



Tabletop Games

- Tangible
- Intuitive
- Face-to-Face



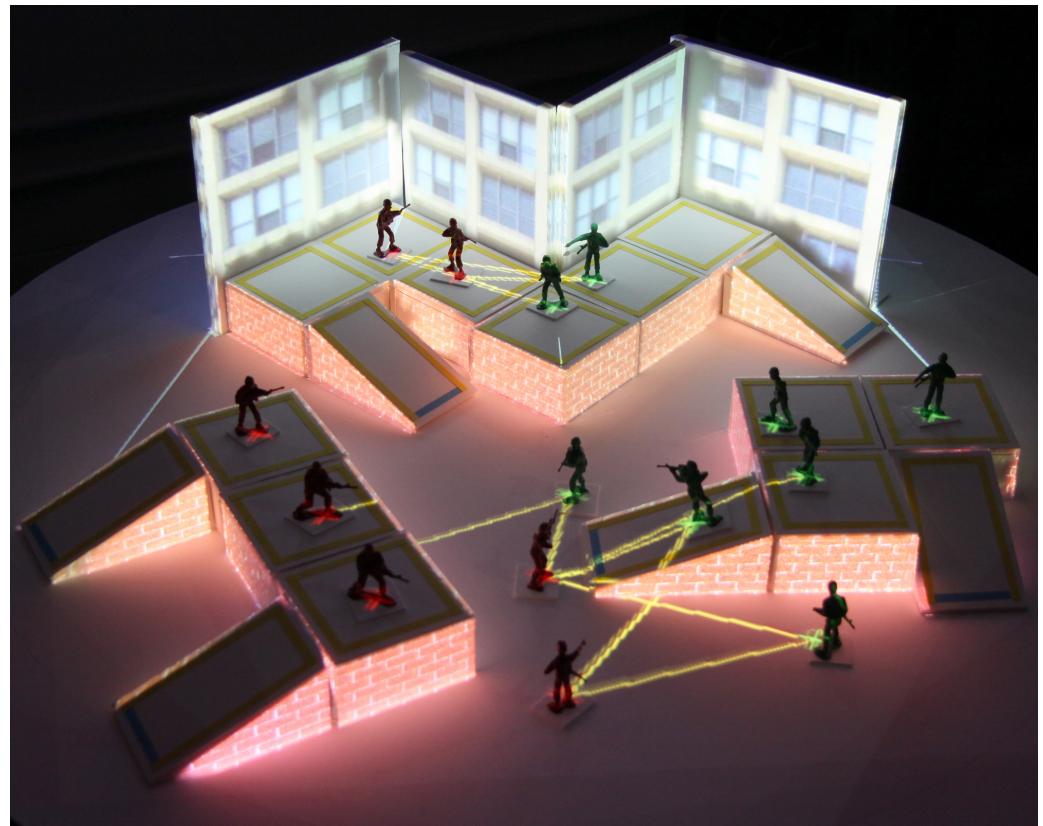
Limited Complexity

- Players as moderators
 - Tedious bookkeeping
 - Error Prone
 - Time consuming



Goals

- Develop an AR strategy game that combines the best qualities of virtual video games and tangible tabletop games
- Evaluate the effectiveness of the augmentation in improving upon a traditional tabletop game experience



Related Work

- LIST A FEW ?

Outline

- ARmy
 - Rules and design
 - Non-augmented version
 - Augmentation
- User study
 - Process
 - Results

Tabletop Miniature Wargame

Warhammer 40,000

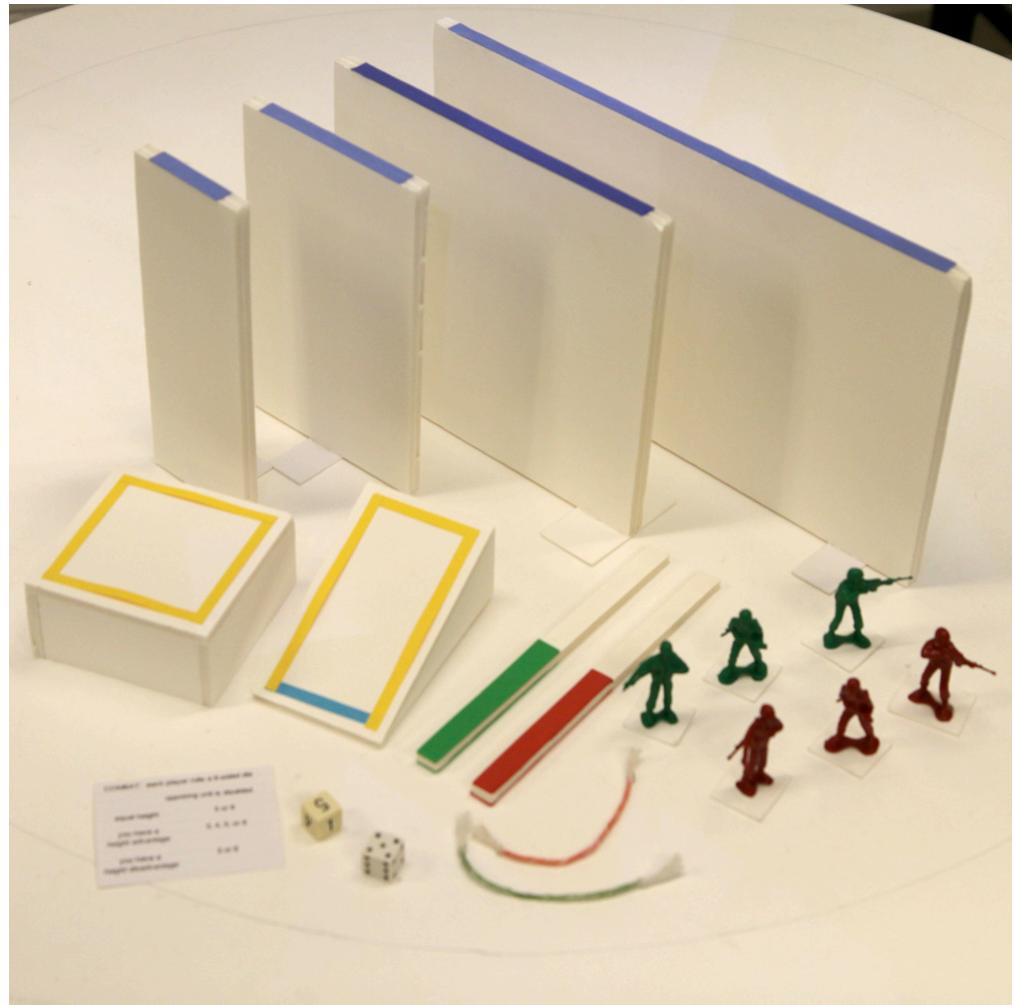


MageKnight



ARmy Game Pieces

- Two opposing armies of 2" plastic soldier "units"
- Battlefield configured from foam-core pieces
 - 8" walls
 - 4" x 4" x 2" platforms
 - 3" x 5" x 2" ramps



Rules: Movement

- Each turn, a player may move any number of units
- Each unit moves a maximum of 4"
- Units cannot move through walls or “climb” up or down the sides of platforms

Rules: Combat

- After movement, all units “engage” with each nearby opponent
 - Maximum range of 8”
 - Must have line-of-sight
- Each unit has 1/3 chance of hitting the opponent, or 2/3 if it stands on higher ground
- A “hit” unit continues battling, and is removed at the end of the round

Non-augmented Play

- Distances are measured using flexible rulers
- Combat outcomes determined by rolling dice

<PICTURES OF DICE AND RULERS>

VIDEO CLIP OF NON-AUGMENTED VERSION

- 30 second clip

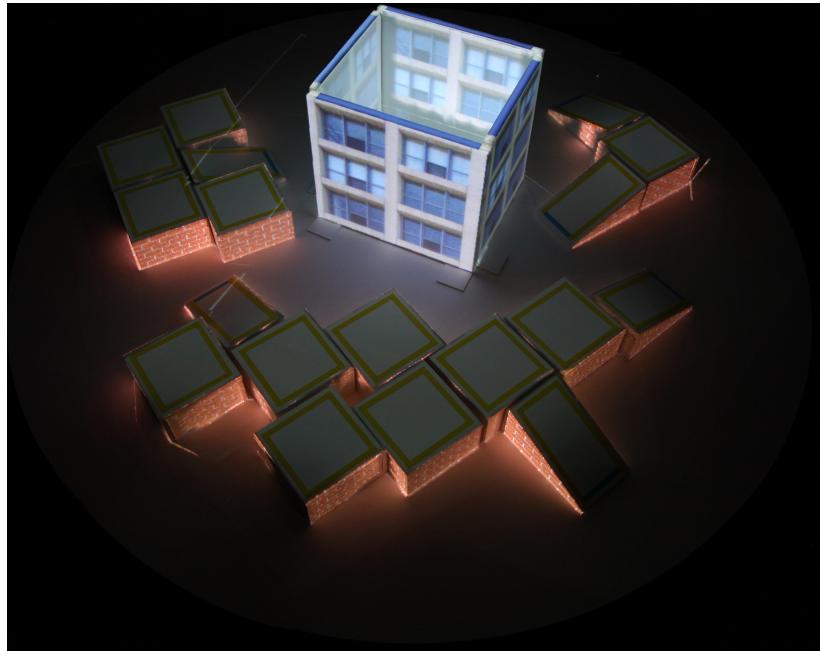
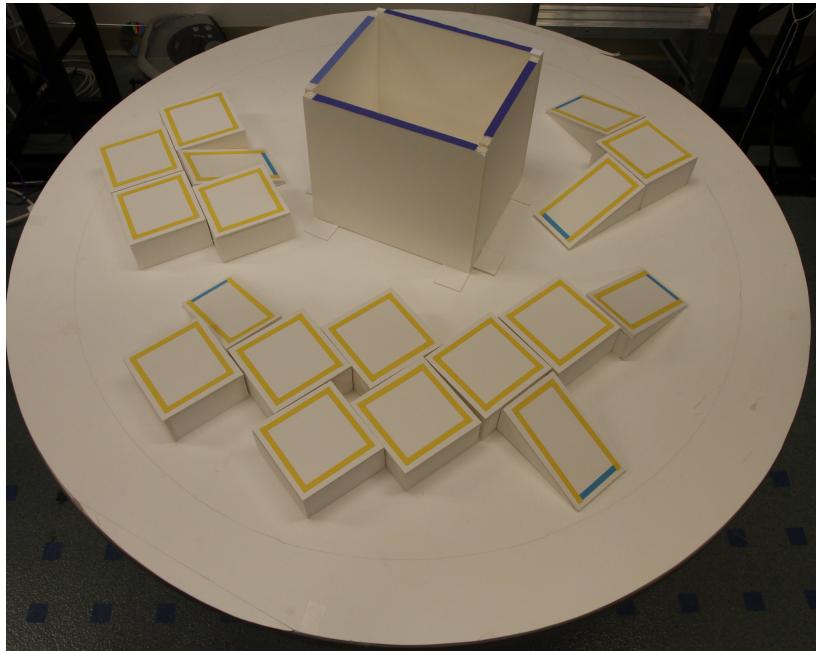
SAR System

- Camera detects objects in scene
- Projectors display images directly onto the dynamic surface



ARmy Augmentation

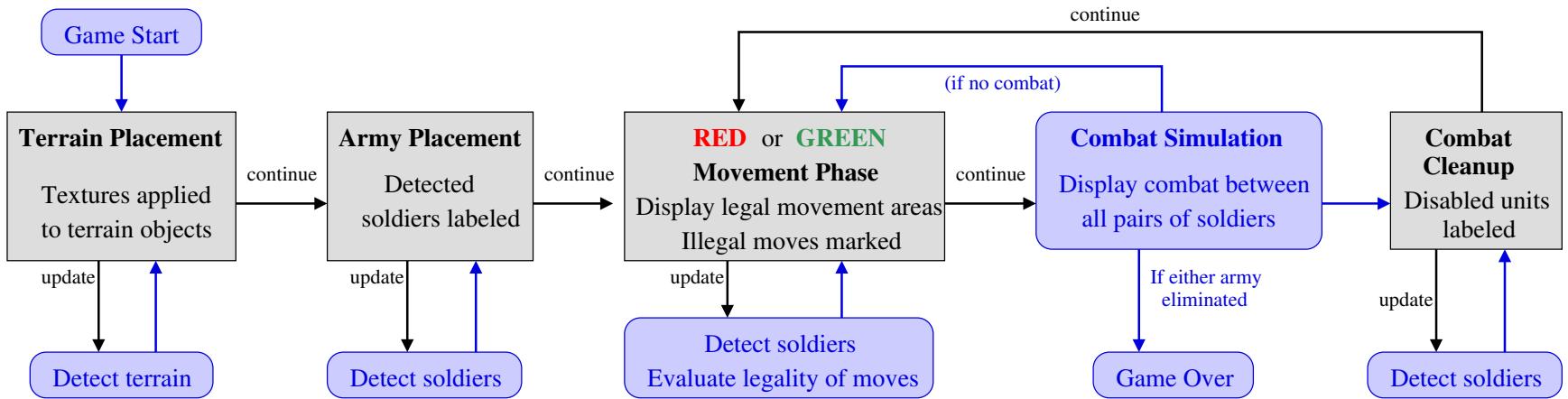
- Track and validate game state
- Convey information
- Apply imagery



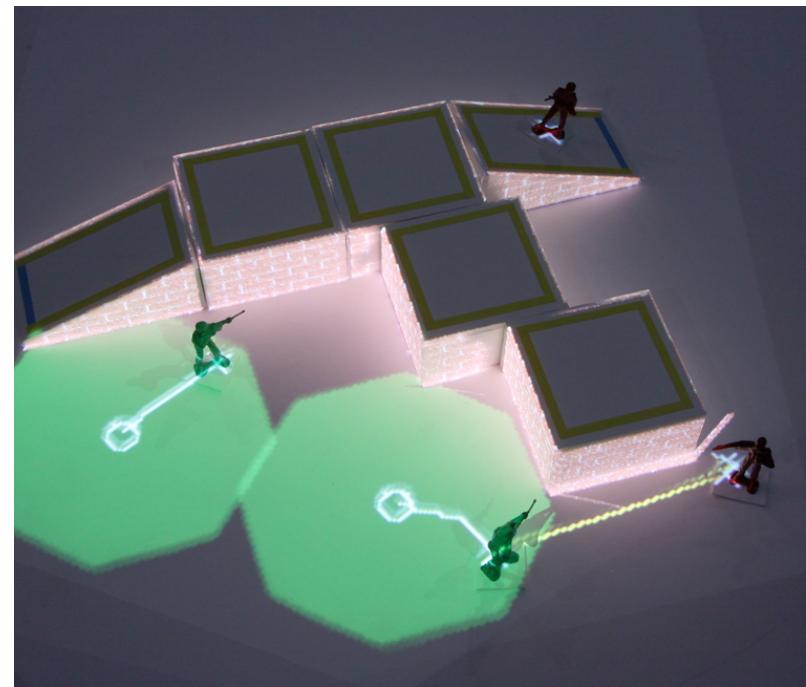
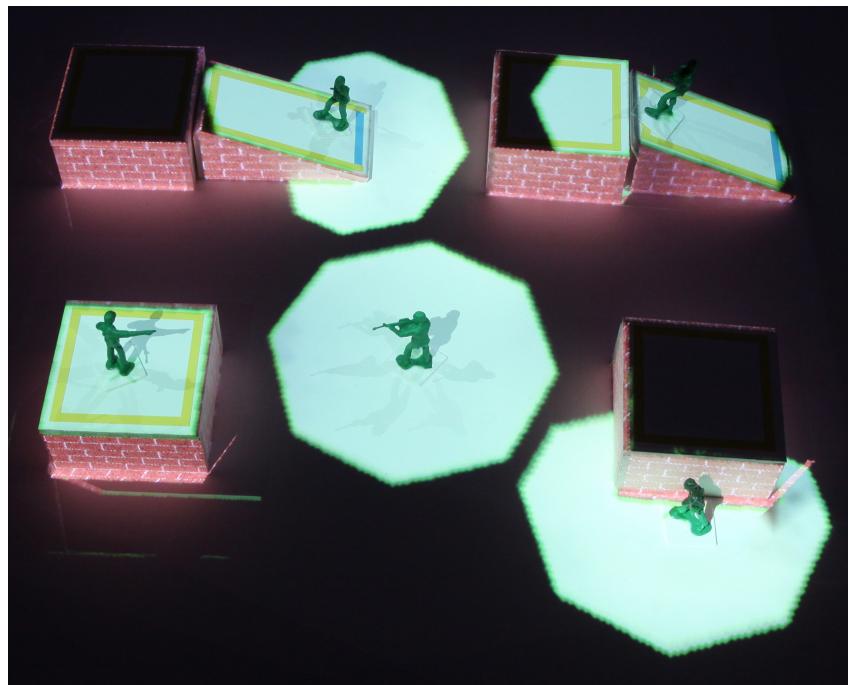
VIDEO CLIP OF AUGMENTED VERSION

- 30 second clip

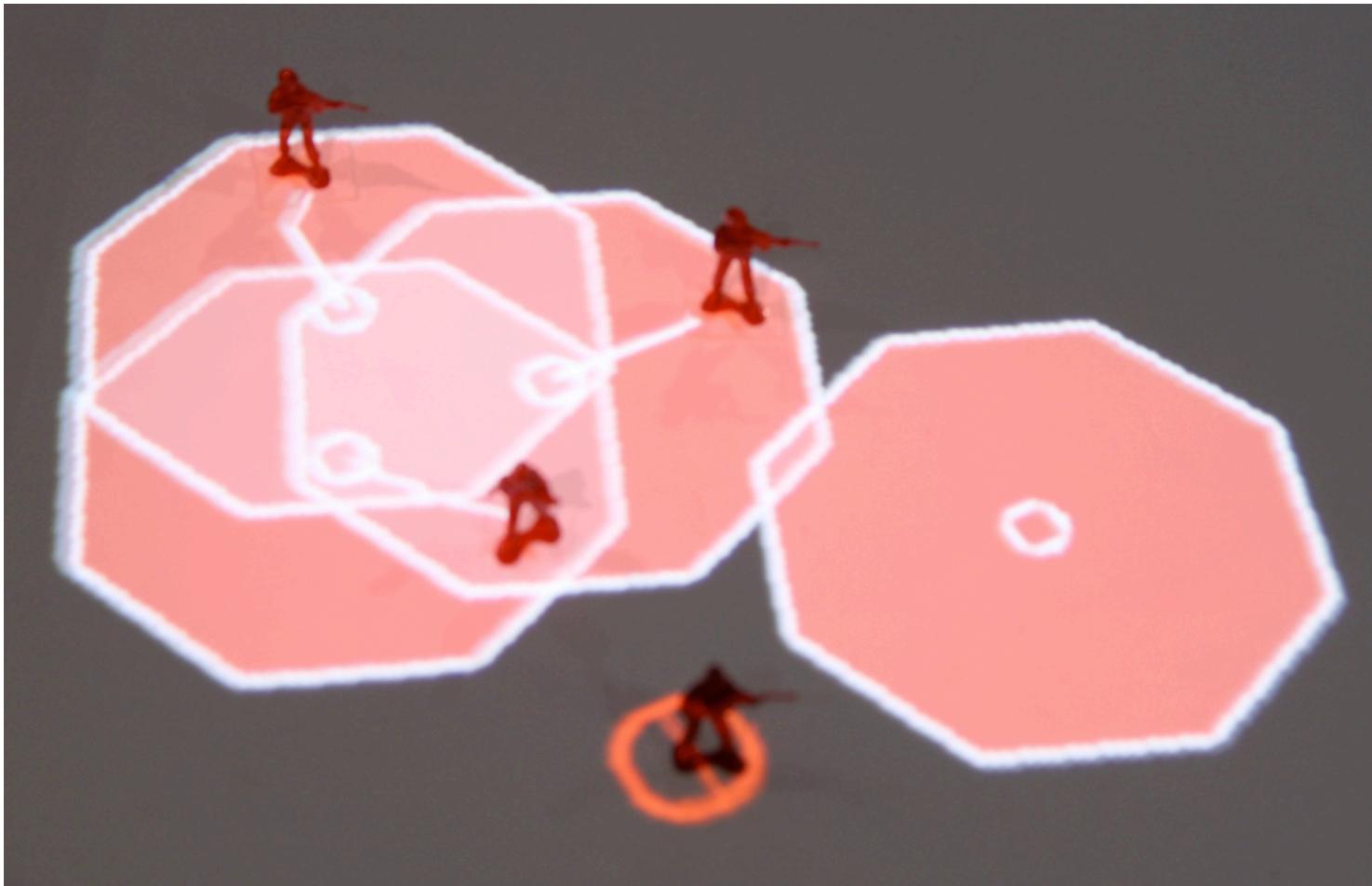
Application Flow



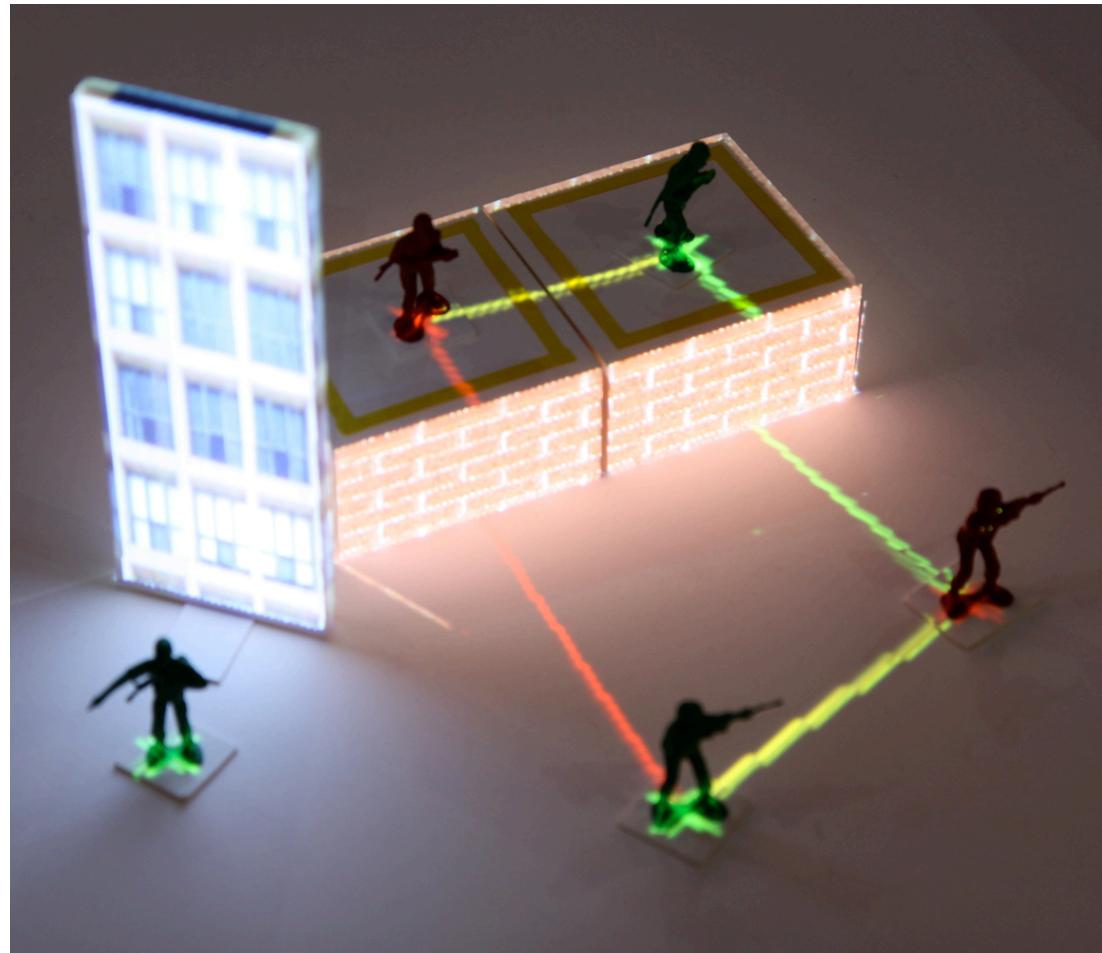
Movement Phase



Illegal Moves



Combat Phase

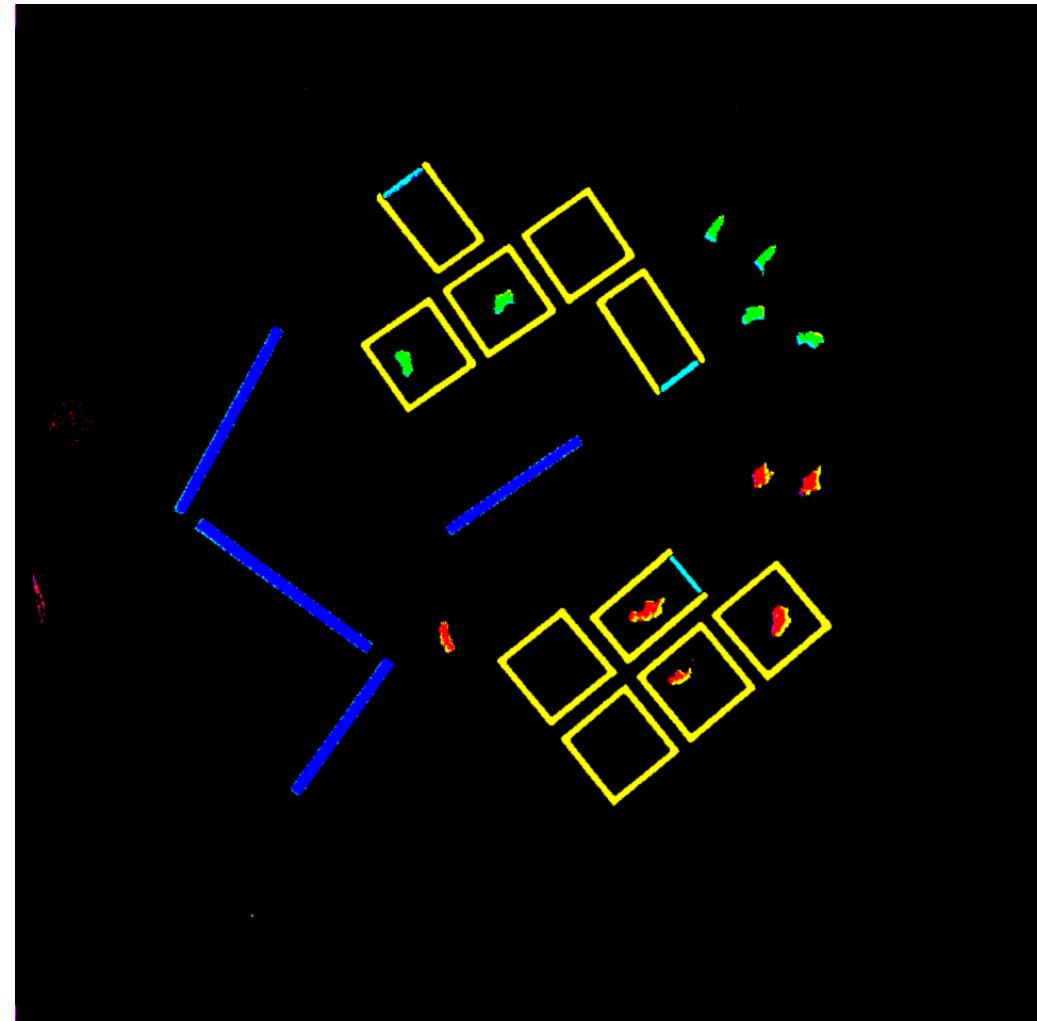


Combat Cleanup

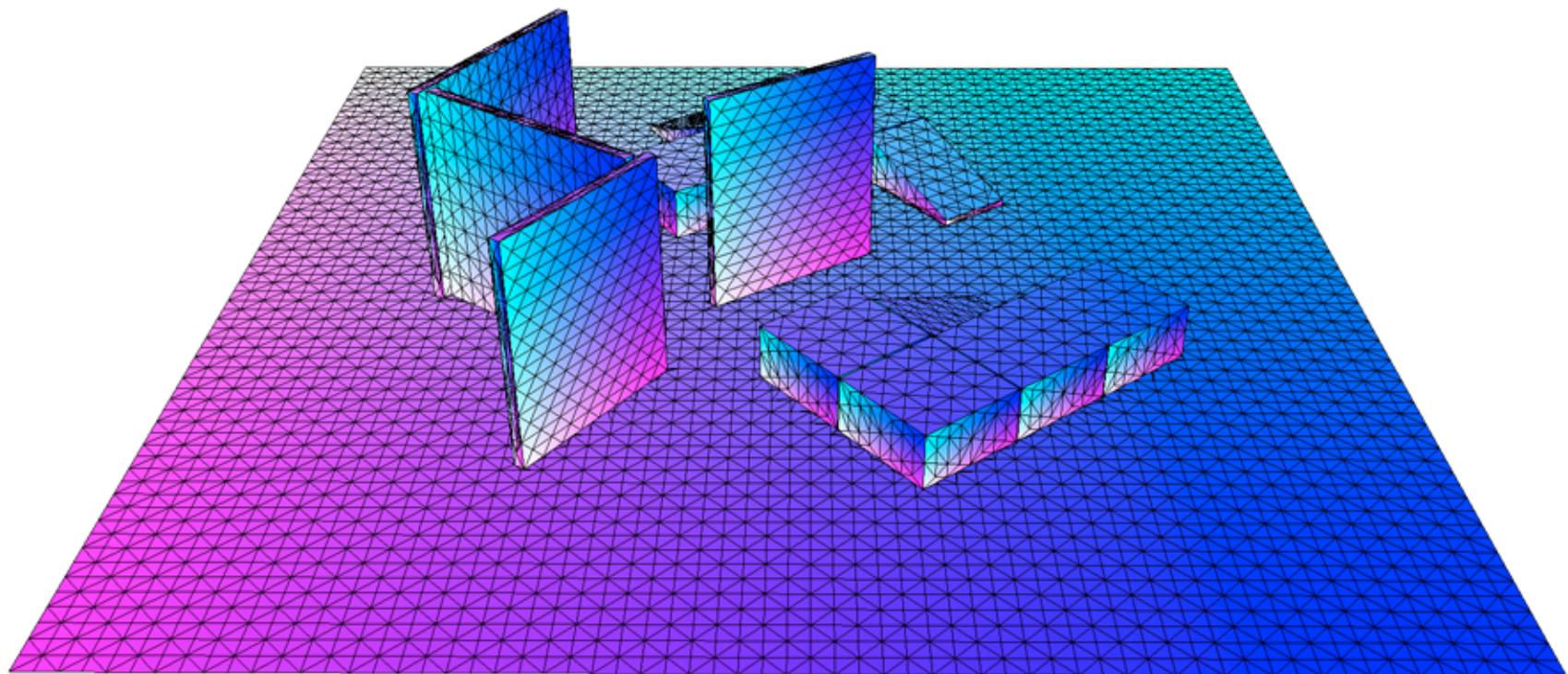


Detection Details

- Detected pieces as colored components
- Why color?

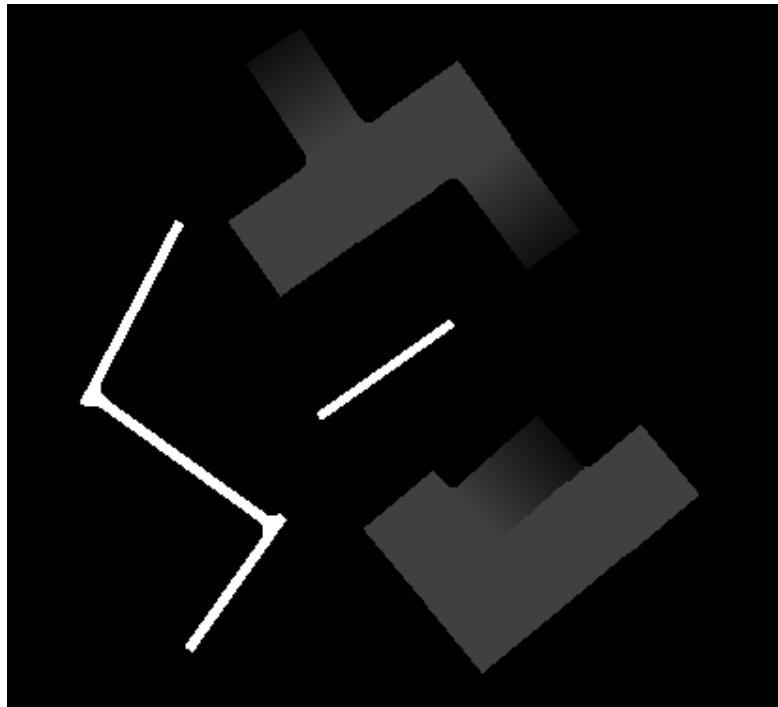


World Model



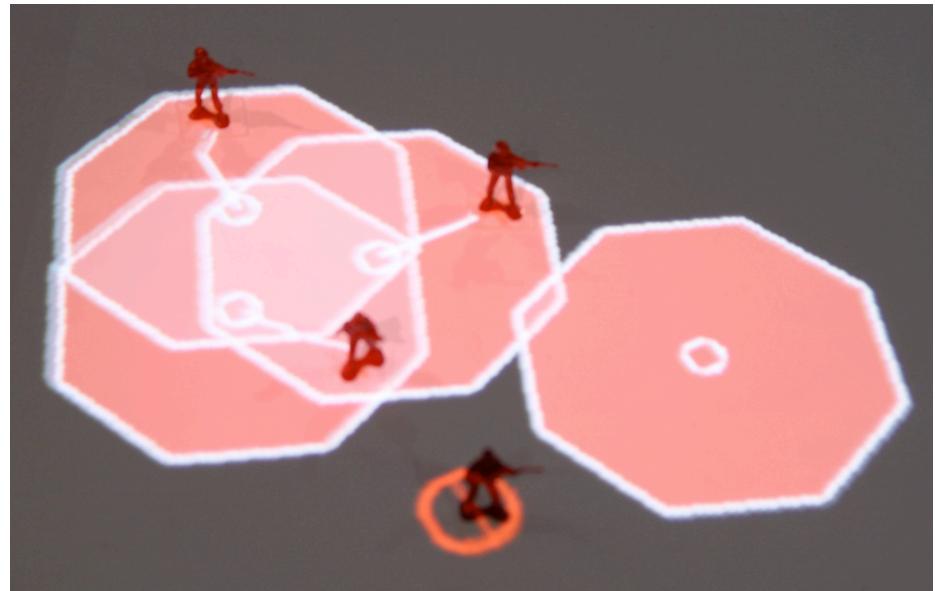
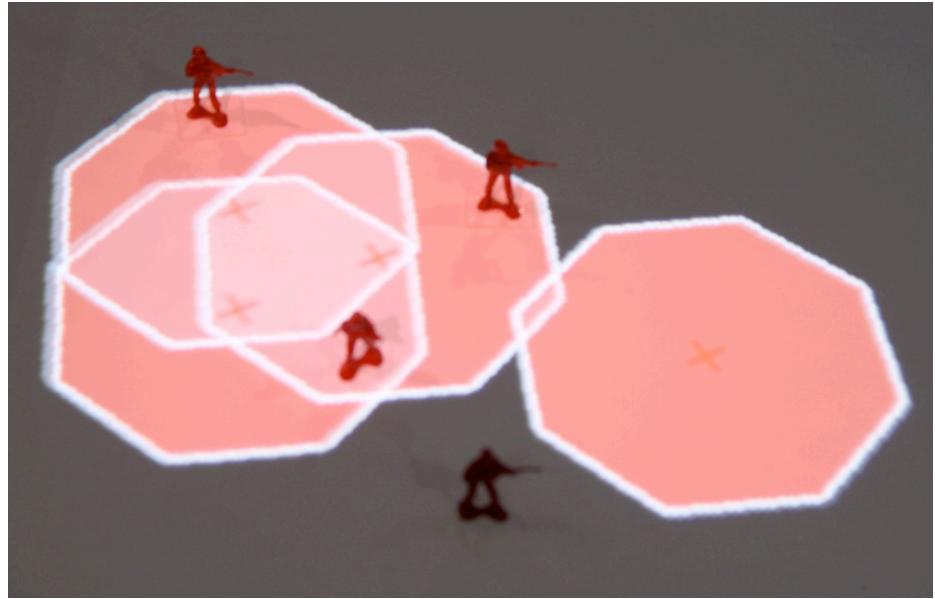
Enumerating Legal Moves

- Construct connected graph from 2D heightfield
- Enumerate legal moves via BFS



Frame-to-frame Matching

- Current tracking does not uniquely identify units
- Deduce likely correspondences using Kuhn-Munkres algorithm



User Study Process

- Explanation of rules (~10 mins)
- “Practice” round (~15 mins)
 - Practice with both versions
- 2 full games in random order:
 - Augmented version (max 20 mins)
 - Non-augmented version (max 20 mins)
- Written questionnaire

Participant Backgrounds

- 18 total (6 females, 12 males)
- Students of Games and Simulations Arts and Sciences (GSAS)
- At least 3 years computer gaming experience
- All have experience playing board games
- Half had prior experience with games similar to Warhammer 40k

User Ratings

Average Rating	Non-augmented All (18)	2 nd only (10)	Augmented All (18)	2 nd only (10)	Delta (all)
Accuracy of distance	3.7	4.0	4.5	4.1	0.8
Accuracy of sight lines	3.8	4.0	4.8	4.6	0.9
Accuracy of rules	3.8	3.9	4.6	4.4	0.8
Subjectivity	4.1	3.9	4.6	4.6	0.6
Interest	3.5	3.9	4.6	4.6	1.1

Timing Data

Averages	Non-augmented		Augmented	
	All (9)	2 nd only (3)	All (9)	2 nd only (5)
Terrain setup	1:16	1:13	2:46	2:07
Army Placement	2:52	2:38	3:03	3:11
Movement phase	0:42	0:36	0:52	0:47
Combat phase	1:33	2:13	0:22	0:18
Single Battle	0:16	0:21	0:04	0:03
# rounds per game	2.3	2.0	3.9	4.1
# battles per game	26.1	24.5	36.6	41.0

Quantitative Analysis of Moves

	Practice Round	Full Augmented Game
Total # Moves	141	537
Moves > 75% Max Distance	90 (64 %)	315 (59 %) (30 – 93 %)
Moves > 95% Max Distance	44 (31 %)	127 (24 %) (0 – 63 %)
Borderline Illegal Moves	8	4
Flagrantly Illegal Moves	0	2
Detection Errors	4	8

Positive Feedback for Non-augmented Game

- “It was a little more hands on”
- “Keep players actively involved in game play”
- “... know exact outcome of dice ...”
- “Felt responsible for the outcome of the dice”
- “slight bending of rules”

Negative Feedback for Non-augmented Game

- “Much slower combat”
- “occasional confusion (even about whose turn it was)”
- “While we made decisions, they were not necessarily the correct ones in terms of the rules.”

Positive Feedback for Augmented Game

- “visualizations were easy to understand”
- “easy to see how far you can move”
- “never unclear about whose turn it was or what could be done”
- “ultimate referee”
- “visually stimulating”

Negative Feedback for Augmented Game

- “waiting for recalculation”
- “Blind spots forced us to simplify our terrain design a bit.”
- “Don’t know the reason the soldier was disabled.”
- “Watched action happen rather than rolling the dice. Takes away your feeling of involvement.”

Conclusions

- Feedback for SAR was generally positive
- System proved fairly robust
- Take care not to remove player involvement
 - Transparent outcomes
 - Decisions

Future Work

- Simultaneous acquisition and display
- More sophisticated games require:
 - Improved object recognition
 - Finer-grain controls
- Application to arbitrary games
- Audio

Questions?

