Augmented Virtuality in Real Time

Alex Stamm Patrick Teall Guillermo Blanco Kevin Thang

AViRT

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All circles are hyperlinked

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Vision

Visual Effects are revolutionizing the way we create films and engage our audience.
But this shouldn't be restricted to the high budget professionals.

Our vision is to:

- inspire independent filmmakers to work with virtual assets
- broaden the possibilities during on-set production
- allow filmmakers to visualize their virtual set
- save the production team time in the post-production process.

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Problem Statement

Indie directors are unable to pre-visualize their virtual set without the funds to pay for a high-fidelity 3D visualization system.

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Research Question

How does an affordable, mobile, and real-time pre-visualization application enhance the film productions of indie film sets?

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Elevator Statement

We have created a low-cost alternative to the previsualization software used in the film industry today by using Google's Project Tango.

The application we developed places the director and actors into the virtual environment during the film’s on-set production process.

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Goals

- Fast and informative pre-production
- Contextual awareness for actors and cinematographers
- Precision in directing
- A simple and aesthetically pleasing application
- No experience necessary for use
- Mobility in a smaller, compact film studio

To develop an application that allows indie directors to perform pre-visualization with considerations for speed and precision.

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Reality Perspective

“The problems facing the visual effects industry are serious and complex, as seen by the number of companies failing on razor thin margins to maintain their businesses and are either closing, or consolidating.” - Mike Seymour

Constraints

- Advanced and costly technology
- Huge VFX teams
- Requires massive communication

Expectations

- Always expecting new innovations
- Agile Film Teams
- Lean Budgets

Any innovation that can expedite the production process and replace costly hardware is not just helpful, but even necessary for these studios to stay afloat and relevant.

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Expectations

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Value of Project

- Create foundation for pre-visualization tools with depth sensing technology
- Give more power to the indie filmmaker
- Open doors for virtual production possibilities
- Save time in post-production

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Stakeholders

- Independent Filmmakers
- Actors
- Students
- Film and Video Studies Department
- Computer Graphics Technology Department
- Purdue University

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Planning

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Roles

Team Leader	**Alex Stamm**	Lead Developer, Compositor, Researcher
Product Manager	**Patrick Teall**	Lead Designer
Coach	**Guillermo Blanco**	3D Modeler, Media Creation
Recruit	**Kevin Thang**	Unity & Android Developer

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Project Management Tools

Task Management	**Trello**
Document Management	**Google Drive**
Communication Tool	**GroupMe**

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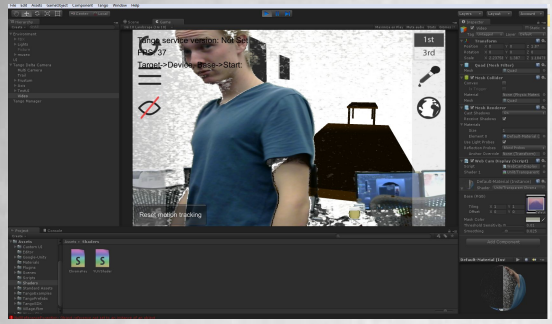
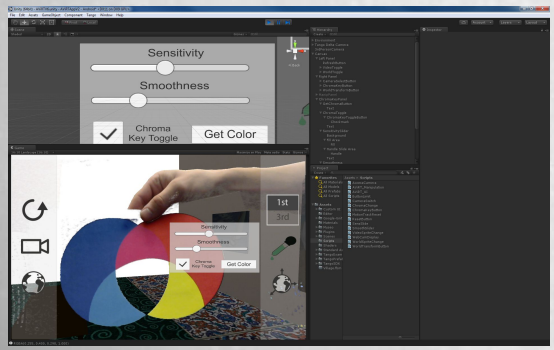
Milestones





* Our Unity Development Environment

- Milestone 1
  - RGB Shader
  - Setup Environment
  - Tango Webcam
- Milestone 2
  - YUV Shader/Chroma Key
  - Added virtual environment
  - UI development
- Milestone 3
  - Color-picker
  - Error check
  - Sprites
  - Reposition UI

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Gantt Chart

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Milestone 1														
Milestone 2														
Milestone 3														
Go No Go														
Secondary Research														
Branding														
3D Environments														
Unity Dev														
UI Design														
Usability Testing														
Analysis														

Statistics Consultation

- Consulation Session with Purdue Department of Statistics
  - Created customized VRUSE questionnaire
  - Developed ethnographic interview questions
  - Reduced usability factors to maintain relevancy
  - Determined expected testing population size
  - Discussed analysis methods

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Misc.

- Preparing Android SDK
- Tango SDK
  - Configuring Motion Tracking Camera and Manager
  - Tango Delta Camera
- Unity Shaders
  - All-in-one Chroma Key Plugin

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Resources

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Envision Center

- Tech Lead - George Takahashi
- Student Researchers -
  - Noah Bannister
  - Dan Anderson
- Project Tango tablet
- Lab computers and appropriate software
- Group meeting space
- Meeting room for conference calls and advisor meetings

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Morales's Greenroom Studio

- CGT Department
  - Optimal local test site
  - Portable green screen provided
  - Commercial filming location
  - Development suggestions
  - Student and alumni participants
- Lightcraft
  - Built into room
  - 3D camera tracking

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Ball State University

- IDIA Lab
  - Consulted with lab director **John Fillwalk**
  - Development suggestions
  - Green room reservation
- Telecommunications Department
  - Green screen feedback
  - Student participants

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Development Resources

- Unity API

- Unity Android API

- Tango API

- Stack Overflow

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Secondary Research

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Tango Hardware

- Area Learning
  - Remembers visual features
  - ADF - Area Description File
  - Prevents drift
  - More accurate than only motion tracking
- Depth Perception
  - Time of flight distance measurement of real world objects
  - Infrared emitter and sensor
  - Point cloud coordinate system (x, y, z)
  - “Not ideal for close range objects or gesture detection.” (Tango API)
  - Problems in bright environments
- Motion Tracking
  - Pose information

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Quality in Previsualization

- Real-time rendering yields lower quality
- Compositing for previs is not as clean
- Processing high-definition takes time

“However, because of the competence of the capturing board on PC, our first prototype can only composite and display movies of standard definition (SD) level in real time. It takes a while until the movies of high definition (HD) level are produced.” (Ichikari 2006)

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Game Engines

“We believe that one answer may lie in the use of game engines as interactive environments in which to preview visual effects and artificial environments.” (Northam 2012)

- Unity vs. Unreal
- Real-time rendering
- Interactive platform

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On-Set Previsualization for Post Production

"There is great desire to use previs tools on-set, so that directors can visualize actors alongside visual effects "(Northam 2012)

- Lightcraft system
  - $200,000 system
  - built into a room, stationary
- Spaceship/Ark issue in film blockbuster *2012*
  - reshooting scenes
  - remaking VFX

"Method Studios president Marc Weigert declared an ambitious goal: Make previsualization inexpensive enough to use for an entire feature film — more specifically, for the cost of no more than two shooting days." (Cohen 2014)

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Context

Using the Tango for Film

- As a VFX tool
  - Affordability of Tango
  - Preventing costly errors in post-production
- Mobile Platform
  - Three dimensional movement
  - General portability
- Indie pre-visualization
  - Can work with make-shift green screen backdrops
  - Actor positioning

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Production

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3D Environment Development

- Maya: software used for 3D animation and modeling
  - Polygon count: less is better
  - Textures done with Photoshop and then imported in Maya
  - Exported as an .fbx file so it can be brought into Unity (unable to model)

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Unity Development

- Video Game Engine with real-time rendering capabilities
  - Implementing 3D environments and lighting
  - Scripts written in C#
  - Shaders written in GLSL (based in OpenGL)
- User Interface programming
  - Vector sprites from Adobe Illustrator
  - Using Project Tango plug-ins
  - Button interaction on Tango

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Android Development

- General
  - Building an APK from Unity
  - Android SDK
- Tango
  - Pose estimation
  - Motion tracking
- Mobile Device
  - Gyroscope
  - Accelerometer

Production Hurdles

- Shaders
  - Calling multiple shaders
  - YUV > RGB color space
  - Writing in GLSL
  - Mathematical boolean > if/else statements
- Scripts
  - Communicating with shaders in C#
  - Inability to call inactive gameobjects
- Building to Android
  - Multiple versions
  - Old SDKs
- Textures
  - FBX missing textures on import
- Sprites
  - Sprite proportions
- Optimization
  - Project sourced from disk faster than network

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Research

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Usability Research

Participant Selection

- Film and Video Studies Students
- Telecommunication Students
- Independent Filmmakers

Components

- Ethnographic Questions
- VRUSE Questionnaire
- Open Ended Questions

Our participants were a mix of students and faculty at Purdue University and Ball State University.

We provided king size candy bars to all participants as incentive

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Usability Test - Contextual Inquiry

Performance Tasks in Virtual Museum

- Key out green screen
- Position the actor in the scene next to the Mona Lisa painting
- Position the actor in the scene next to the Persistence of Memory painting

Usability Metrics

- Task Success
- User Errors
- Subjective Satisfaction

Each participant was debriefed, the tests were recorded from two perspectives to pick-up application interaction, facial response and oral commentary for later review.

*Tests were conducted in full-sized green rooms with production quality lighting

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Post Evaluation Questionnaire VRUSE

- Customized VRUSE
  - Likert Scale
  - Reduced questionnaire from 100 to 69 questions
  - Omitted online help usability section
  - Omitted user instruction usability section
  - Omitted simulator sickness diagnostic section
- Added open ended responses
  - Tailored questions to film industry
  - Interaction with green screen
- User Completion
  - 10-20 minutes to complete
  - Anonymous responses
- Recorded and compiled through Qualtrics

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Open Ended Responses

- **Purpose of application**

All answers aligned with what we considered as the most important purposes of the application

- **Use on a film set**

For the director, as a green screen camera, for planning the set and movement of the cameras, and for actor rehearsal.

- **Establishing context**

Avoids film and render time for immersion into the virtual scene and provides a clear relationship between actor and virtual set.

- **Mixed-reality engagements**

1st person movements and made the shots and actor direction no longer feel arbitrary.

- **Consideration of VFX after Tango interaction**

All participants felt excited and comfortable to begin incorporating VFX and green screen shots into their personal film productions.

- **Broadened possibilities**

AViRT broadens the ability for directions to work with actors to create a scene, shortens the pre-production phase.

- **Speed or precision**

There was a perfect split of importance because neither speed or precision should be sacrificed.

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Discovery

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Hardware Limitations

- Overheating
- Crashing
- IR Sensitivity
- Battery Life
- 0.5-4m Range

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Camera Angle

- Physical camera - angled slightly upward
- Virtual camera - pointed straight forward, still tracks accurate movement
- Result - actors appear ungrounded
  - World Manipulation on y-axis added to mitigate problems
  - Physical movement does not fully absolve issues
- Proposed solution - virtual camera angle needs to match physical camera angle

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Virtual Drift

- Tango motion tracking is still in development
  - Occasionally becomes unresponsive
  - Lack of stable visual features causes over-compensation
- Solution - Reset motion tracking

Swipe/Zoom Capability

- Touch controls are assumed
- During usability testing, participants would instinctually...
  - swipe left and right
  - pinch to zoom/scale

- Solution - Touch controls need to be implemented for further ease of use

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Desire for Recording

Our participants anticipated the ability to record their scenes rather than having a temporary previsualization.

A recording of the screen as well as a tracking of the motion through 3D space would be very helpful to the post production to achieve the original vision of the director.

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Chroma Keying

Lighting and color scheme from reality doesn't match the one from the virtual set.

- Color Correction
  - Actors would have a better blending with the 3D environment
  - More realistic result
  - Colliders could also be added to these walls
- Matte Manipulation
  - Choke
  - Feather

Analysis

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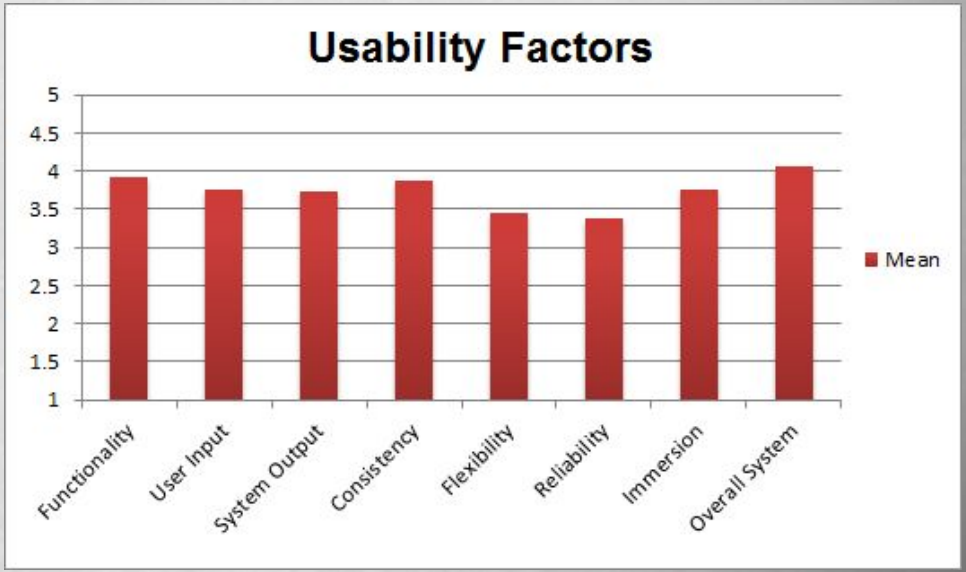
VRUSE Usability Factors Analysis

Usability Factors	Max	Min	Score ± SD
Functionality	5	1	3.92 ± 0.87
User Input	5	1	3.76 ± 0.88
System Output	5	1	3.73 ± 0.81
Consistency	5	1	3.88 ± 0.91
Flexibility	5	1	3.45 ± 0.88
Reliability	5	1	3.39 ± 1.03
Immersion	5	1	3.76 ± 0.86
Overall System	5	1	4.07 ± 0.68

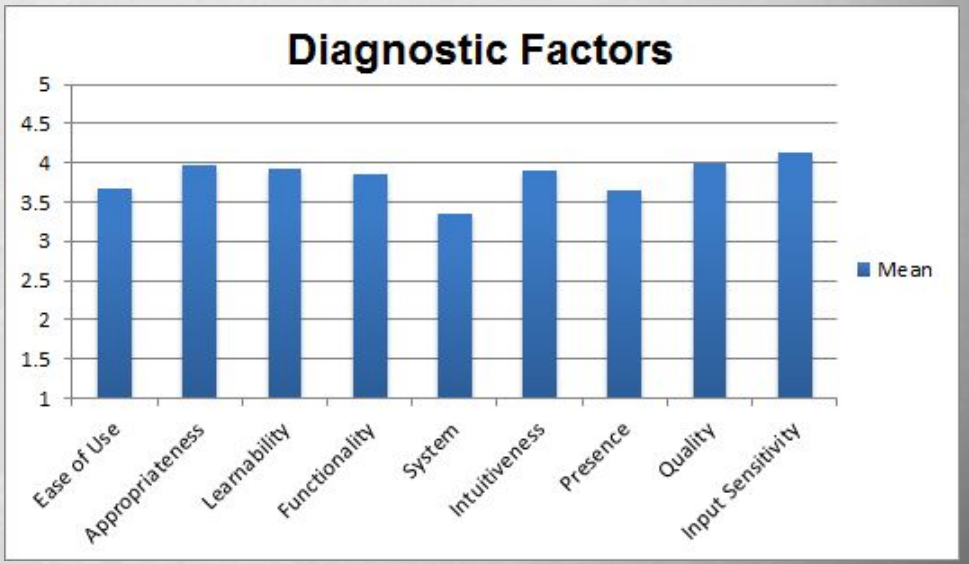
5	4	3	2	1
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree



VRUSE Diagnostic Factors Analysis

Diagnostic Factors	Max	Min	Score ± SD
Ease of Use	5	1	3.67 ± 1.01
Appropriateness	5	1	3.98 ± 0.77
Learnability	5	1	3.93 ± 0.93
Functionality	5	1	3.86 ± 0.82
System	5	1	3.36 ± 0.69
Intuitiveness	5	1	3.90 ± 0.74
Presence	5	1	3.64 ± 0.92
Quality	5	1	4.00 ± 0.58
Input Sensitivity	5	1	4.14 ± 0.38

5	4	3	2	1
Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree



Speed and Precision

In a professional film production, speed is one of the most important concerns for the entire team, as time is money.

In the stage of previsualization, and based on the results from participants response, there is an **equal necessity** for speed and precision

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Other

Quotes

Words from Users

“If this were available on the app store I might be willing to pay up to $20”

From Cinematographers

“Don’t let yourself become too obsessed with technology. Find a balance with your creativity.”
Jerzy Zielinski, ASC, PSC

From Jordan Cronenweth: “Minimize compromise, be prepared for rejection, and save your money”
Thomas A. Del Ruth

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Credits

George Takahashi - Sponsor, Technical Lead/Research Programmer, Envision Center

Esteban García - Advisor, Assistant Professor, Computer Graphics Technology Department

Dan Anderson - Graduate Research Programmer, Envision Center

Noah Bannister - Graduate Research Programmer, Envision Center

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Demonstration

Enter this number into browser to watch demo from your mobile device

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