Digital Reach Whitepaper

Expanding the Canvas
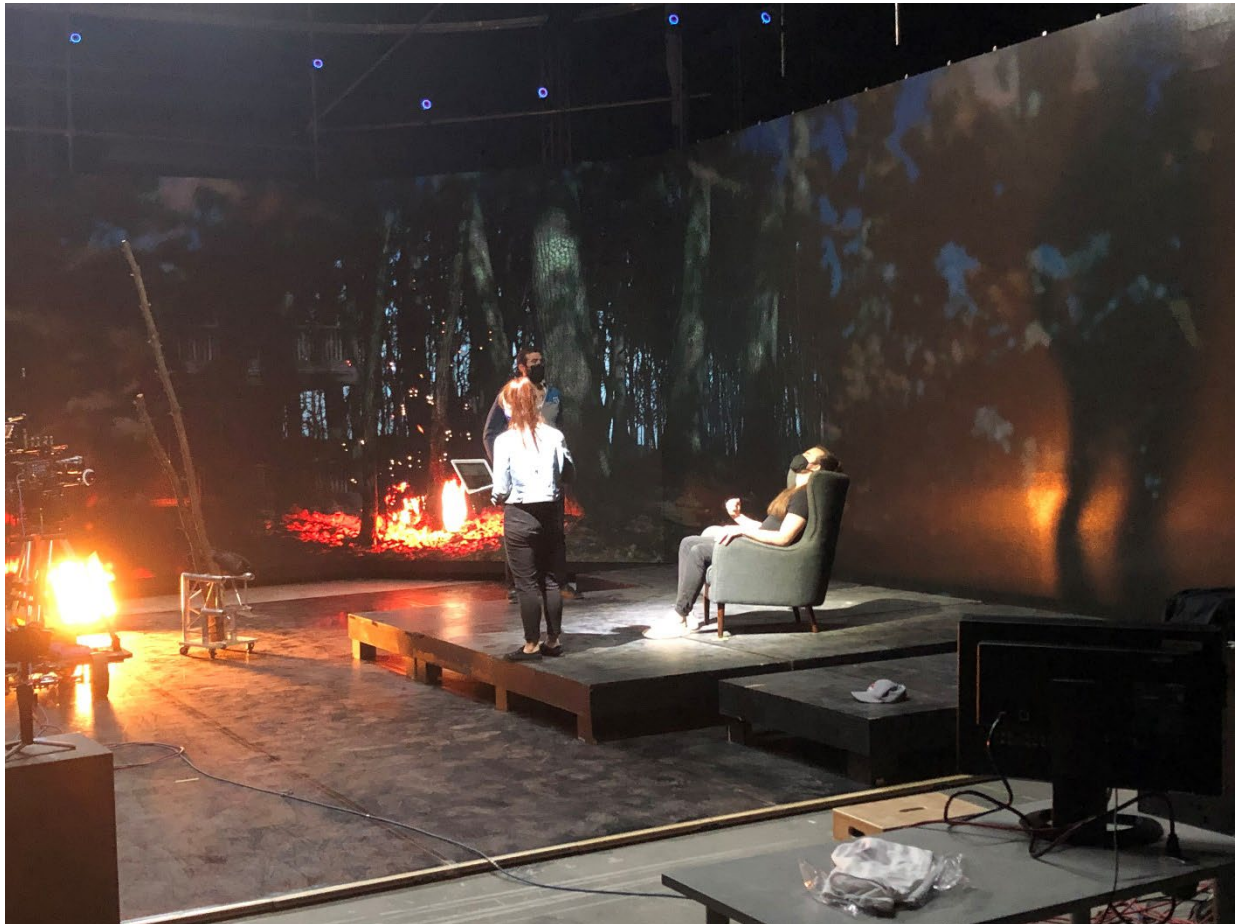

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Definitions

Maturity Level: A technology's maturity level indicates age, development and growth of a product or workflow. It has been rated using the following scale from emerging technologies to most developed.

Infancy, Moderate, High, Established

Level of Deployment: This metric indicates the complexity and level of expertise required in order to effectively utilise a product or workflow. It is rated using the following scale.

Beginner, Intermediate, Advanced, Expert

Introduction

About the Digital Reach Project

This initiative addresses the persistent challenges of capturing and distributing live content (performances, rehearsals, lectures, interviews, behind-the-scenes footage) to Canadian, and global audiences. The project will demonstrate how arts institutions can develop content for greater audience engagement. Participating arts organizations would explore opportunities to engage with content aggregators to determine the potential for distribution to Canadian and foreign markets. The project will also explore new and emerging technology and how it relates to both online content and live performance.

The following white paper is the result of the creative exploration of technology and art. The intent of the paper is to outline the available technologies, what the technologies are and can do, their level of maturity and what may be required from a staffing perspective to implement within and organization.

About Expanding the Canvas

Expanding the Canvas is a multi-disciplinary, creative incubator led in partnership by The National Ballet of Canada, The Royal Opera House, Sheridan College's Canadian Music Theatre Project, Canadian Opera Company and Screen Industries Research and Training Centre (SIRT).

Expanding the Canvas collaborated with artists who are interested in exploring ideas that have the potential to be grounded within technology and the digital space and who are interested in creatively exploring and rethinking the changing world that we live in at the intersection of technology and their artistic practice. The incubator aims to create space for the exploration and integration of technology into the creative process and artistic practices

This project was possible through funding from:

Technologies

Motion Capture

Overview

Motion Capture technologies can be used to capture or track the movement of the human body, quadrupeds and inanimate objects in three-dimensional (3D) space. Data can be recorded and played back using 3D software or streamed in real-time to visualisation software, game engines or mobile devices. In the field of science this data can be used to analyse velocity, contortions, angles and/or other specific movements of the human body or objects. The sports industry leverages motion capture to train, compare, and examine an athlete's form during a particular exercise; for example during a golf swing. The entertainment industry often utilises motion capture to translate an actor's movement in the real world to that of a CG character in a virtual world. Additional components can be added to capture a more robust data set including actor audio, facial performance and hand movements. The addition of these elements typically augments the captured data to be considered [Performance Capture](#) data (see below). More recently the technology is being used in Virtual Production environments to capture both actor movements and to track the position of a virtual camera or digital cinema camera for In-camera visual effects.

Two main methods of capturing motion capture data exist; optical based systems and inertial based systems.

Usage
Body Capture, Object Tracking, Camera Tracking, Room scale Virtual Reality

Major Vendors
Optical: [Vicon](#), [Optitrack](#)
Inertial: [Xsens](#), [Rokoko](#)

Minor Vendors
Optical: [Phase Space](#), [Qualisys](#)
Inertial: [Perception Neuron](#), [Ultium](#)

Maturity Level
High. Various systems and vendors exist for numerous industry applications.

Level of Deployment
Intermediate to Advanced

Costing
Optical: $20,000 - $1M
Inertial: $5,000 - $15,000

Staffing

One (1) motion capture technician is required at minimum to setup, run and capture using any system. Inertial or suit based systems may not need more than one technician though in some circumstances it may be beneficial to have one technician per performer. Optical based systems similarly need only one technician, though with larger systems (also known as Volume) multiple technicians will improve efficiency.

When real-time streaming to a third party application additional technicians are required to operate systems receiving streamed data.

Use Cases

Motion Capture for Videogames
https://www.youtube.com/watch?v=bB9pOOHaN3c

Motion Capture in Cinema (Gollum from Two Towers)
https://www.youtube.com/watch?v=w_Z7YUyCEGE

Violet Disruption - Expanding the Canvas digital avatar prototype at SIRT
https://www.youtube.com/watch?v=Fd982GEFWWA&list=PLbvVPbC1RJnn7vbBbnoNswYDH72z6nmJy&index=15

Performance Capture

Overview
Performance capture technologies are used to capture all of the elements associated with an actor's performance. Performance Capture includes audio recording, facial performance capture using a special head mounted camera rig (HMC), and a more advanced motion capture system or system add on which includes finger tracking. This data can be streamed live into other softwares such as a game engine or can be recorded and processed later for a higher fidelity result. The Entertainment industry leverages this technology for cinematics and films that make use of high fidelity digital characters. Performance Capture technologies can be used in combination or as individual components to be used in stand alone applications.

Usage
Facial Capture, Finger Tracking, Audio Recording, Data Streaming

Vendors
Facial Capture
Faceware
Rokoko face capture
Unreal FaceLink
iClone

Hand Capture
Stretch Sense
Manus Gloves
Ultra Leap

Audio
Suggested Audio Package for capturing 1 actor (links to some vendors)
- x1 Lav Mic
    - Sennheiser G4
    - Rode Wireless Go
- x1 Boom Mic & Pole
    - Rode NTG 5
    - DPA Pencil Mics
- x1 Recorder
    - Sound Devices 833
    - Zoom Podtrak P4

Suggested Audio Package for capturing 2+ actors
- x1 Lav Mic per Actor
- x2 Boom Mic & Pole
- x1 Multi-channel Recorder
    - Sound Devices Scorpio

- [Zoom F6](#)

Maturity Level

Moderate - Some vendors exist and are cemented in this area. Methods to combine and synchronise components from different vendors are more experimental or proprietary.

Level of Deployment

Advanced

Costing

Facial Capture: Headmounted Camera and software: $5,000 - $30,000
Hand Capture: $2,000 - $5,000 per pair of Gloves
Audio Equipment: $2,000

Staffing

Performance Capture is a highly scalable capture practice with a non-linear workflow. It can be accomplished by single performer Indie style actors, or large scale film or video game cinematics. The following examples indicate a variety of technician roles which may or may not be required based on application size.

Motion Capture technician to setup, monitor and capture the body performance. If multiple actors are involved there may be additional motion capture technicians, however this ratios is not 1:1.

Head Mounted Camera (HMC) Technician to setup, monitor capture and adjust the HMC system. This technician ensures accurate capture of facial performance. An experienced technician can monitor up to 6 facial video feeds.

Hand Performance Technician may work in conjunction with Motion Capture, or may be integrated. However if the workflow is separated (body capture separate from hands) this technician may be utilised at a different part of the pipeline.

Audio Department may consist of one (1) recordist, and one (1) or two (2) boom operators. The recordist operates the Recorder and often sound mixing equipment to capture audio at the correct volume level, while boom operators carry microphones and follow the actors performance on set. Audio department often has their own closed audio channel allowing technicians to more easily communicate through headphones.

Use Cases

Performance Capture in Cinema (Avatar)
https://www.youtube.com/watch?v=1wK1Ixr-UmM

Alita Battle Angel BTS
https://www.youtube.com/watch?v=hOMuRopLgxg&t=27s

Detroit Become Human BTS
https://www.youtube.com/watch?v=8136CxSh5Ps

Xanadu YouTube Channel
https://www.youtube.com/c/xanaduBlu

Projection Mapping

Overview

Projection mapping is the art of utilising video projectors to map projections and light to multiple surfaces at various depths. The process itself uses compositing, video editing software and other 3D manipulation tools to control where the light is emitted and cast upon your scene. Typical applications include live events/attractions, marketing displays and art installations or experiences. This process may make use of multiple projectors working in sync to cover a larger area. Experiences are often synchronised with other media including audio, laser projection, pyrotechnics or additional light displays.

Usage

Compositing, Visual Experiences, Augmenting physical Spaces

Major Vendors

[Epson](#)
[Sony](#)
[Derivative - Touch Designer](#)
[Samsung](#)

Minor Vendors

[Rhino 3D](#)
[Vankyo](#)
[Bomaker](#)

Maturity Level

High

Level of Deployment

Advanced

Costing

Projectors - $200 - $20,000
Software - $300 - $2,200

Staffing

One technician is needed to understand the technology and software integration. Knowledge of 3D softwares and compositing is a great asset for this application as well. Advanced knowledge of light mapping and display controls is a requirement for initial setup and calibration.
A technician with Audio/Video background would be required for medium to large scale deployment of systems, especially if dealing with multiple projectors, displays or workstations running the experience.
Graphic Designers or artists contribute creative input to art installations.

Use Cases

Interconnection
https://www.youtube.com/watch?v=a1v4W95wJnM

NBA Allstar Show
https://www.youtube.com/watch?v=qzR0HEjCrrI

Rescape Light Art Experience
https://www.youtube.com/watch?v=utKynou7wuQ

Box
https://www.youtube.com/watch?v=lX6JcybgDFo

Large Scale Projection Backgrounds (LED Walls)

Overview
With the advancements of graphical processing units (GPU) come new opportunities to explore the use of real-time rendering for large scale displays. First utilised in the mainstream by Disney's Mandalorian, ILM Stagecraft combines real-time rendering with game engines to display 360 degree virtual worlds inside an enclosed LED Volume. This concept can be applied to displays ranging in size from desktop to theatre to create a window into a virtual environment. In combination with other technologies these real-time backgrounds can be updated to show a particular perspective, become animated or even be interacted with by outside actors.

Usage
Backgrounds / Backdrops, windows, set extensions, interactive displays

Major Vendors
Software: Unreal Engine, Unity
Hardware (Displays): Roe, Infiled, Sony, Samsung,

Minor Vendors
Software: Maya, DaVinci Resolve, Houdini,
Hardware: Desay, Crestron, Absen

Maturity Level
Infancy - Moderate

Level of Deployment
Expert

Costing
$200,000 - $5M

Staffing
Display Hardware Specialist: Individuals responsible for the build and setup of LED wall infrastructure including LED panels, Cabling and Processors
Smart Stage Engineer: Responsible for system Networking, hardware networking video matrix (if applicable) and render node connectivity
Game Engine Technician: Management and deployment of real-time 3D assets onto displays. Integration of any of the following if applicable; Camera tracking, motion capture, game logic, DMX or real time dynamic lighting
Video Engineer: Alternative to Game Engine Technician displays may be running pre-recorded video content. Content must be ingested and synchronised over multiple displays, and managed for playback during production.

<u>Motion Capture Technician:</u> Management of tracking system build and operation. Responsible for objects or persons being tracked within the space

Use Cases

Virtual Production on Mandalorian Season 1
https://www.youtube.com/watch?v=gUnxzVOs3rk

Empire of Wild - Expanding the Canvas Prototype at SIRT
https://www.youtube.com/watch?v=BYwrcLa03-0&list=PLbvVPbC1RJnn7vbBbnoNswYDH72z6nmJy&index=12

CoPilot Co - Imagine (Shot at SIRT)
https://www.youtube.com/watch?v=k9V5YRn_ssg

Large Scale Projection Backgrounds (Projection)

Overview
With the advancements of graphical processing units (GPU) come new opportunities to explore the use of real-time rendering for large scale displays. This concept can be applied to displays ranging in size from desktop to theatre to create a window into a virtual environment. In combination with other technologies these real-time backgrounds can be updated to show a particular perspective, become animated or even be interacted with by outside actors.

Usage
Backgrounds / Backdrops, windows, set extensions, interactive displays

Major Vendors
Software: Unreal Engine, Unity

Minor Vendors
Software: Maya, DaVinci Resolve, Houdini,

Maturity Level
Infancy - Moderate

Level of Deployment
Expert

Costing
Free - $4,000

Staffing
Game Engine Technician: Management and deployment of real-time 3D assets onto displays. Integration of any of the following if applicable; Camera tracking, motion capture, game logic, DMX or real time dynamic lighting
Video Engineer: Alternative to Game Engine Technician displays may be running pre-recorded video content. Content must be ingested and synchronised over multiple displays, and managed for playback during production.

Use Cases
Unreal Build: Virtual Production 2020 Full Length Sizzle | Unreal Engine
https://youtu.be/KcNaMY_oi08

Childish Gambino Creates a Fantasy World for Pharos | Project Spotlight | Unreal Engine
https://www.youtube.com/watch?v=DTAW0i7NSoo

Biometrics

Overview

Many consumer level products exist today working in conjunction with smart phones to deliver individual user feedback for health, entertainment and relaxation. Many products offer Software Development Kits (SDKs) allowing developers to obtain body measurements and calculations from a device, and leverage it for alternate applications.

Usage

Brain activity monitoring, heart rate monitoring, velocity measurements, Eye tracking,

Major Vendors

Muse, Tobii,

Minor Vendors

IDR&D, Mantratec

Maturity Level

High. Various systems and vendors exist for numerous industry applications.

Level of Deployment

Intermediate to Advanced

Costing

$100 - $1,000

Staffing

Software Developers: Pending complexity of the application one or multiple software developers are required for SDK implementation and application development. Based on the device being used different coding language skills may be required.

Use Cases

Kinetic Sculpture Garden - Expanding the Canvas Prototype
https://youtu.be/in6H9o4LlnU

How Tobii Dynavox eye tracking works
https://www.youtube.com/watch?v=Y7_f-pR8SBY

Virtual Reality

Overview
Virtual reality technology immerses users in a computer generated simulation of a three-dimensional image or environment which can be interacted with in a seemingly real or physical way by a person using special equipment, such as a head mounted display or controllers to simulate hand movement. The system has inside out tracking or an optical tracking system in order to simulate real world movements such as locomotion and orientation of the user's head. Typically this has been used for gaming due to the ability to interact with things in the virtual world, however training, simulation as well as social or multi-user networked experiences are becoming more prominent.

Usage
Interaction, Solo experience, Multi-player Immersion, Fantasy Worlds, Immersion, Tracking

Major Vendors
[Meta (Oculus)](#)
[Valve](#)
[HTC Vive](#)

Minor Vendors
[HP](#)
[Playstation VR](#)

Maturity Level
High - Commercially available for nearly a decade

Level of Deployment
Intermediate

Costing
$500 - $1500

Staffing
Minimum one developer would be required to create a VR experience using a game engine such as Unity or Unreal Engine. Scale of the experience would dictate the size of the team but 5-10 developers is typical for medium sized application development. Skills in game design, 3D modelling and coding are required to design, create and implement computer general simulations to a VR headset. Optimization of 3D assets and coding is an area of focus when developing content for VR headsets since commercial units typically have mobile processors on board, requiring applications to be well managed.

During exhibition operators who are familiar with both VR hardware as well as the experience itself should assist patrons in and out of the headset and experience. Assisting

patrons to navigate through menus and ensuring they do not become disoriented or ill during the experience is typical for public exhibition. Sanitation of hardware between users should be considered.

Use Cases

Horizon Call of the mountain
https://www.youtube.com/watch?v=zxvsl34f_HM

SandboxVR
https://www.youtube.com/watch?v=7eMtxD9haE4

360 Video

Overview
360 video technology is video recording where a view in every direction is recorded simultaneously. 360 videos are typically viewed via personal computers, mobile devices or dedicated head-mounted displays. Users can pan around the video by clicking and dragging. On smartphones, internal sensors such as gyroscope can be used to pan the video based on the orientation of the device. On head-mounted displays a tracking system aligns the user's head orientation with the view, creating an immersive experience.

Usage
Vlog Content, Real Estate Photography/Videography, VR Experiences, Immersive works of art

Major Vendors
[Insta360](), [Go Pro](), [Ricoh Theta]()

Minor Vendors
[Vuze]()

Maturity Level
Advanced. Multiple vendors exist with content on multiple platforms.

Level of Deployment
Beginner to Intermediate

Costing
$400 - $10,000

Staffing
Camera operator : To setup and frame the shot. The camera operator has knowledge of camera lensing, and experience with viewing 360 content in order to create compositions which feel natural to the viewer based on the intended medium. For example a project intended for viewing on Desktop might have different considerations then a project intended for viewing in a headset. Camera locomotion and positioning play an important role in how the audience will experience the final product. When viewing 360 video content in a headset, users may be subject to nausea or motion sickness.

Editor: May be used to reframe footage for better camera angles and to focus audience interest. Editors stitch footage together and export content for delivery. 360 video editors have experience with traditional editing using non-linear editing software and often have basic skills in compositing or visual effects in order to overcome typical challenges such as camera rig removal, seam stitching or stitch offsets.

If Stereoscopic or 3D video is the intended end result both the camera operator and editor positions become more advanced. Knowledge of stereoscopic workflows and video pipelines is recommended for data management, content creation and deployment. 360 video products can also be enhanced with immersive sound recording or mixing including the use of ambisonic or binaural microphones to more closely simulate spatialized audio.

Use Cases

Immersive 360 experiences
https://www.youtube.com/watch?v=sPyAQQklc1s

First Virtual Reality Ballet in the World - NIGHT FALL (360 video)
https://www.youtube.com/watch?v=xCp4at6LE0A

A GoPro Adventure in Les 3 Vallees
https://vimeo.com/277989198

IT'S TIME (Tiny Planet Music Video)
https://www.youtube.com/watch?v=AyzjlTH9csM

Volumetric Capture - Videogrammetry

Overview
Videogrammetry is the process of surrounding a dynamic actor with cameras and greenscreens in order to superimpose them. By having them surrounded by a multitude of cameras, you collect data of that actor from all angles. This allows you to orbit around the video as a 3D asset. Use cases include mixed reality, virtual reality or interactive content viewing. At a lower level, this type of technology can be used to live composite yourself into an environment such as virtual reality or for performance.

Usage
Holograms, Mixed Reality, Interactive

Major Vendors
[Microsoft](#)

Minor Vendors
[Liv](#)

Maturity Level
Moderate - Used by indie developers at small scale, or high productions at very high budget. Data management and processing pipelines are still experimental.

Level of Deployment
Expert

Costing
$1000 - $1,000,000

Staffing
Volumetric Capture requires a team of camera and workstation technicians depending on studio size. Video data is in the Gigabytes or Terabytes per minute therefore a sophisticated data management system is required. Technicians are proficient in camera operation and settings, as well as studio lighting infrastructure and operation for optimal capture.

Post-Production includes a team of technicians to offload and process video data and convert it to 3D content. A specialised workflow is developed for content playback and review.

Final implementation would depend on deliverable. Game Designers and software engineers may be required to deploy content to virtual experiences, head mounted displays or interactive platforms.

Use Cases

Madonna Performance
https://www.youtube.com/watch?v=9Z1GdMuC9E8

Mixed reality capture studio
https://www.youtube.com/watch?v=dXs4PrWpQoM

Universe Within
http://universewithin.nfb.ca/desktop.html#index

Game Engines and Real-time Visualisation

Overview
Game Engines are softwares primarily used for the development of video games, mobile applications and interactive projects. Offering a variety of tools and features geared towards the development of games they may include a rendering engine, a physics engine, sound, scripting, animation, artificial intelligence, networking, streaming, and much more. With the advent of real-time rendering many other industry sectors have begun implementing Game Engine's into their workflows including architecture, automotive, virtual-humans, automated agents and motion picture production.

Usage
Game Creation, Cinematics, Computer Generated Imagery, Virtual Production, Pre-Visualisation

Major Vendors
[Unreal Engine,](Unreal Engine) Unity

Minor Vendors
Gamemaker, Construct

Maturity Level
High. Various systems and vendors exist for numerous industry applications.

Level of Deployment
Intermediate to Advanced

Costing
Free - $200

Staffing
Game Engine Technician: Management and deployment CG assets into game levels. Integration of any of the following if applicable; Camera tracking, motion capture, game logic, animation.

Use Cases
Breakdown | "Project Ember" Unreal Engine 5 short film
https://www.youtube.com/watch?v=0gcSxscH0I8

Real-Time In-Camera VFX for Next-Gen Filmmaking | Project Spotlight | Unreal Engine
https://www.youtube.com/watch?v=bErPsq5kPzE

Unreal Engine Virtual Dance Motion Capture Production Making Film (MASSA CREW)
https://www.youtube.com/watch?v=IpikqyH5Txg

Photogrammetry

Overview

Photogrammetry technologies can be used to obtain reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena. In the field of Archaeology overhead photography has been widely applied for mapping surface remains and excavation exposures at archeological sites. The video game industry leverages photogrammetry to create photorealistic environmental assets for video games; for example in *The Vanishing of Ethan Carter*.

Photogrammetry workflows can be combined with other scanning workflows for a more precise capture of reality including LiDAR scanning.

Usage

3D Modelling, Real Estate, Forensics, Engineering, Rapid Prototyping

Major Vendors

Technology Esper, Peel 3D
Software Reality Capture , Agisoft Metashape , Autodesk ReCap

Minor Vendors

Technology Polycam,
Software AliceVision Meshroom, Pix4D, Regard 3D

Maturity Level

High. Various systems and vendors exist for numerous industry applications.

Level of Deployment

Intermediate - Advanced

Costing

Technology $1,000 - $250,000
Software Free - $3,500

Staffing

One (1) Photogrammetry artist is required minimum to setup, run and capture using any system.
3D Artist: Required to be able to convert a scan of an object or character and process them to become a usable asset in either a game engine or other medium.

Use Cases

Photogrammetry for Videogames
https://www.youtube.com/watch?v=U_WagCBp9zo

Photogrammetry for 3D printing
https://www.youtube.com/watch?v=N6MnahQFJKk

Logan - Digital Doubles for Cinema
https://www.youtube.com/watch?v=-13Y2Pe7kFs