




5/7 Femoral Canal Reaming



Progress: 00

Operation Start

Action Name

Time: 0 Sec

Objectives:

- Preparation for Canal Reaming
- Reaming of the femoral canal
- Uncemented Broaching of the femoral canal



MAGES Platform SDK
Documentation

Transform virtual training, reform real medicine
“do, repeat, learn”

Table of Content

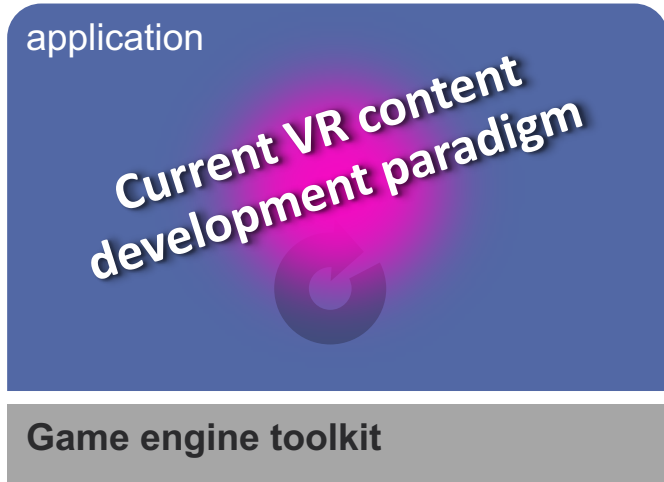


- Our unmatched proprietary technology.....
- Multilayer with geometric Algebra Transformations.....
- Analytics Engine.....
- Gamified Rapid Prototyping.....
- Educational Curriculum.....
- Semantic representation of medical applications.....
- License system.....
- SDK class diagram.....
- Rigid and Deformable Object interaction.....

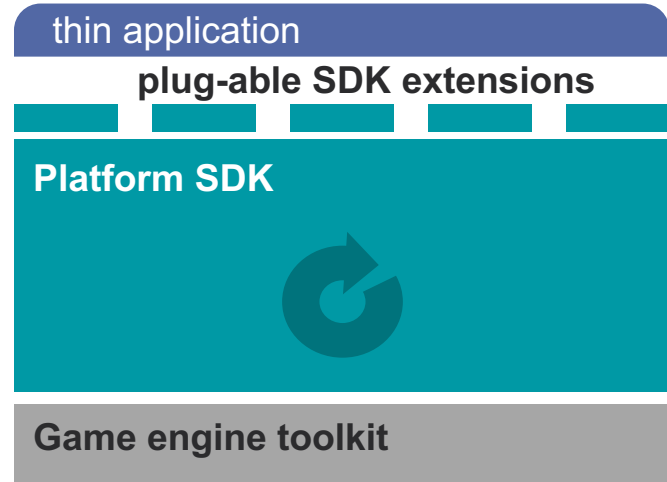
Our Platform SDK novelty head start



platform SDK: ↑ reusability, ↓ creation time, ↓ creation effort



- *Content developers need to be expert game engine programmers*
- *Difficulties in integration*
- *Duplication of application state*
- *Difficult code reuse and weak extension model*

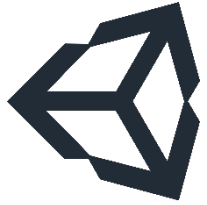


- *VR content creators don't have to be expert programmers*
- *curbing complexity: customisations, replacements, extensions*
- *rapid prototyping: cutting development time*
- *Massive code reuse & design reuse for other verticals*

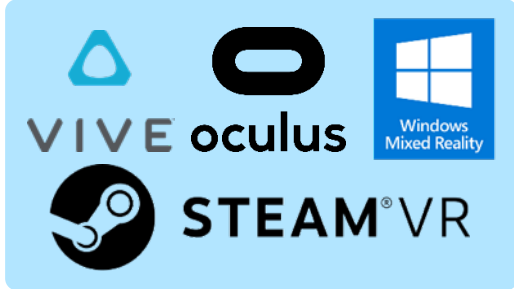
Current rapid prototyping via our SDK



Unity Engine



VR HMDs



VR production pipeline



SDK



Rapid Prototyping



Learning modules



Generated medical
training simulators

Our Platform SDK novelty head start (fourth iteration published)



JRama VR Transforming Medical Education and Training with VR using M.A.G.E.S.
George Papagiannakis^{1,2,3}, Nick Lydatakis^{1,2,3}, Steve Kateros^{1,2,3}, Stelios Georgiou^{1,2,3}, Paul Zikas^{1,2,3}

The Problem

- Expensive training Model
- Limited Surgical Simulation

Our solution

- Reduce surgical costs
- Reduce training costs
- Democratize and extend VR training

Platform SDK exposing M.A.G.E.S.

References

Eurographics 2014: J. Boulos, J. Sego, and E. Anderson Education Paper

gIGA: an OpenGL Geometric Application framework for a modern, shader-based computer graphics curriculum

G. Papagiannakis^{1,2}, P. Papanikolaou^{1,2}, E. Greassidou^{1,2} and P. Trahanias^{1,2}

¹University of Crete, Computer Science Department, Voutes University campus, 70013, Heraklion, Greece
²Foundation for Research and Technology Hellas, 100 N. Platanos Str., 70013, Heraklion, Greece

Abstract
This paper presents the appearance gIGA (OpenGL Geometric Application framework), a lightweight shader-based, comprehensive and easy to understand computer graphics (CG) teaching C++ system that is used for educational purposes, with emphasis on modern graphics and GPU application programming. This framework with the accompanying examples and assignments has been employed in the last three semesters in our different courses at the Computer Science Department of the University of Crete. Greece. It encompasses four basic educational and six optional, referring to an outstanding undergraduate project built on top of gIGA for the creation of an Augmented Reality Environment, in which life-size, virtual characters exist in a marker-less real scene. Subsequently, we present the learning results of the adoption of the CG framework by both undergraduate and postgraduate university courses as far as the success rate and student grasp of major modern, shader-based CG topics is concerned. Finally, we summarize the novel educative features that are implemented in gIGA, in comparison with other systems, as a medium for improving the teaching of modern CG and GPU application programming.

Categories and Subject Descriptors (according to ACM CCS): K.3.2 [Computers and Education]: Computer and Information Science Education—Computer Science Education.

1. Introduction

Computer Graphics (CG) is a topic that not only requires from students a background in science, engineering and basic mathematics, such as linear algebra, but it also demands sufficient C++ application programming skills. The major changes in graphics lie over the past few years have led to significant changes in the new ways CG is now written as well as taught in university courses. CG has been part of the major academic curriculum of the computer science department at the University of Crete during the last 20 years. It has also been a major topic of research which had also led to the organization of CGI in 2004 and Eurographics in 2006 by the University of Crete. Over these years we had experimented with various methods of teaching computer graphics [AS12] from the algorithmic approach, to the survey approach and recently the programming approach. We have adapted and extended the modern, shader-based OpenGL (GSL) approach from [AS11] and opted for a completely revised undergraduate and graduate course curriculum in CG, focusing on the recent, exciting GPU-based languages and APIs.

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VHD++ Development Framework: Towards Extendible, Component Based VR/AR Simulation Engine Featuring Advanced Virtual Character Technologies

Michal Ponder^{1,2}, George Papagiannakis^{1,2,3}, Tom Molet^{1,2,3}, Nadia Magnenat-Thalmann^{1,2,3}, Daniel Thalmann^{1,2,3}

¹Virtual Reality Lab (VRlab)
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^{1,2,3}MIRA Lab
^{1,2,3}University of Geneva
³email: {name.surname}@miralab.unige.ch

Abstract
This paper presents the architecture of the VHD++ real-time development framework that after several years of intensive research, design, and development effort has been released and enters its validation phase. This paper discusses the key aspects involved in architectural structure, design and practical implementation of an efficient, flexible and extendible real-time software framework based on the modern 3D game-engine design principles. This framework supports researchers and application developers with rapid, component based development of VR/AR systems featuring advanced virtual character simulation technologies. The discussion covers motivation, main concepts, survey of related work, the main functional and design requirements, design principles and key architectural elements. It concludes with the initial validation results including overview of existing VHD++ based VR/AR system character simulation applications.

1. Introduction: The Demand

The very recent revolutionary advancements in computer graphics and in real-time virtual character simulation technology put a completely new light on the VR/AR systems and in particular on their scaled down common interactive video games. In the extremely complex environment there is only one rule to follow: deliver always, never, faster and always more in shorter time. Chasing that continuous high demand leads to system complexity rising exponentially with the number of components and increasingly distinct technologies being integrated under a single interactive, real-time, audio-visual application roof. This explains the current, rapidly growing interest of both research and industry in advanced, complexity curbing, framework

2. Motivation: Curbing Complexity

2.1. Common Experience: Facing Complexity

Carrying on proprietary research activities while being at the same time involved in demanding, tightly timed, development projects targeting concrete applications is a daily reality of many research groups. Overall complexity of the resulting applications reaches the levels that one can barely handle with the methodologies currently at hand.

- Papagiannakis, G., Zikas, P., Lydatakis, N., Kateros, S., Kentros, M., Geronikolakis, E., Kamarianakis, M., Kartsonaki, I., Evangelou, G., 2020. MAGES 3.0: Tying the knot of medical VR. In ACM SIGGRAPH 2020 Immersive Pavilion (SIGGRAPH '20). Association for Computing Machinery, New York, NY, USA, Article 6, 1–2. DOI:https://doi.org/10.1145/3388536.3407888, 2020
- Papagiannakis, G., Lydatakis, N., Kateros, S., Georgiou, S., and Zikas, P., 2018. Transforming Medical Education and Training with VR using M.A.G.E.S. In Proceedings of Siggraph Asia '18 Posters, Tokyo, Japan, December 04-07, 2018 <https://doi.org/10.1145/3283289.3283291>
- Papagiannakis, G., Papanikolaou, P., Greassidou, E., and Trahanias, P., gIGA: an OpenGL Geometric Application framework for a modern, shader-based computer graphics curriculum. Eurographics2014, Education Papers, 1–8, Strasbourg, April 2014
- Ponder, M., Papagiannakis, G., Molet, T., Magnenat-Thalmann, N., Thalmann, D., " VHD++ Framework: Extendible Game Engine with Reusable Components, for VR/AR R&D featuring Advanced Virtual Character Simulation Technologies", Proc. of Computer Graphics International03, pp. 96-104, IEEE Computer Society Press, Tokyo, July 2003



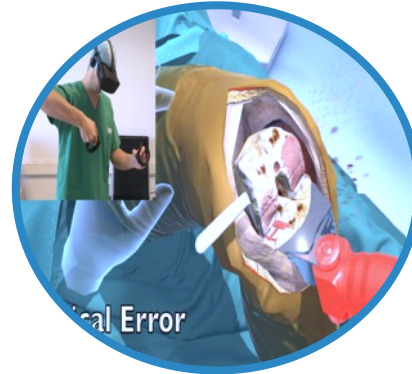
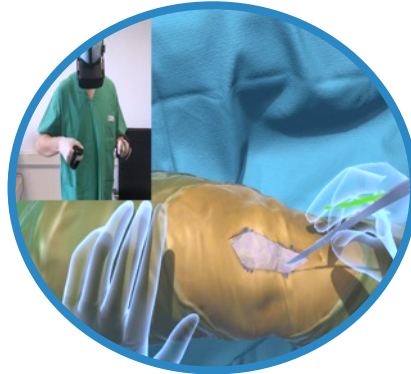
Proprietary technology



- M**ulti-player, proprietary shared virtual collaborative engine
- A**nalytics custom layer with **unique** cloud-based **assessment**
- G**amified Geometric Algebra for **fastest 3D transformation**
- E**ducational **curriculum editor** for **novel** visual scripting
- S**emantic **VR software prototyping** design **patterns**

Our patentable **MAGES™** IP technology

encapsulated in our award winning* **ovidVR SDK**



MAGES: M.A.



Multi-player, shared virtual collaborative operating room

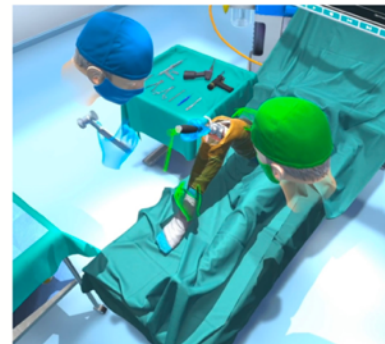
Our innovative networking layer, allows cooperative operations.

Our Custom **Conformal Geometric Algebra** (CGA) GPU interpolation engine groups transformations under a single mathematical framework:

$$T = 1 - \frac{1}{2}te_{\infty} \quad R = e^{-b\frac{\phi}{2}} \quad D = 1 + \frac{1-d}{1+d}e_{\infty}^{\wedge}e_0$$

New character vertex position = $T * R * D$

- ✔ Network data transfer
- ✔ Interpolation quality
- ✔ 7+ simultaneous users



Analytics engine with cloud-based assessment



Another novelty is our own Analytics engine with **cloud-based user assessment** to track, monitor and present important feedback regarding each gamified operation.

- ✔ Unlimited user event tracking and analysis

MAGES: G.E.S.



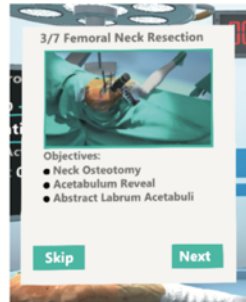
Gamified rapid prototyping

Medical operations can be **modeled**, **modified** and **generated** through scriptable nodes using our custom visual scripting editor.

- ✓ Coding-free SDK
- ✓ Content creation

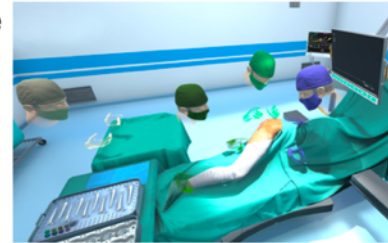


Educational Curriculum



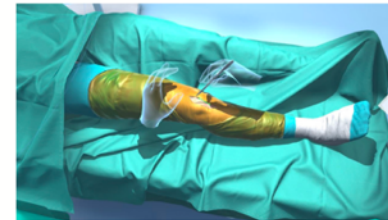
Our products integrate an educational curriculum to **enhance knowledge and skills**.

- ✓ Adaptive visual guidance
- ✓ Gamification elements
- ✓ Curriculum Objectives
- ✓ Live webinar support
- ✓ Scoring system



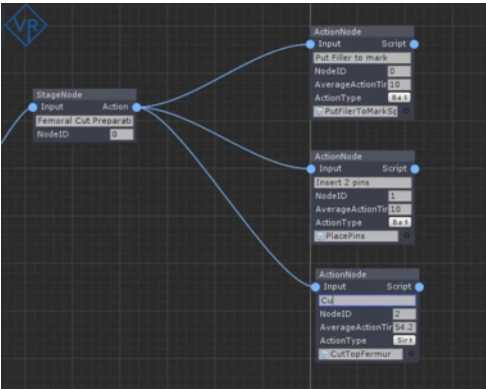
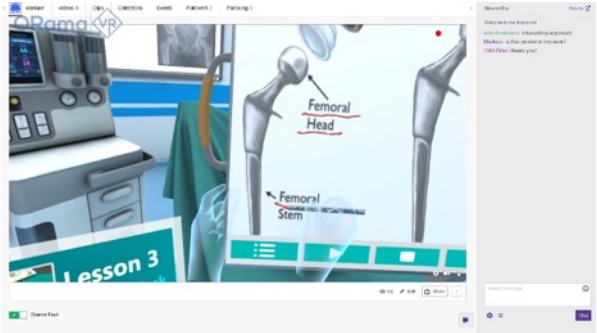
Semantic Representation of Medical Operations

By **prototyping commonly used patterns** and surgical techniques we managed to create a **customizable platform** able to populate new content with minimal changes.



Our unmatched proprietary technology

- M**ulti-player, Co-op featuring multiple users.
- A**nalytics engine with cloud-based user assessment.
- G**amified rapid prototyping based on Geometric Algebra.
- E**ducational Curriculum enhancing knowledge and skills.
- S**emantic representation of medical operations.



Why a platform SDK?

Current VR content development

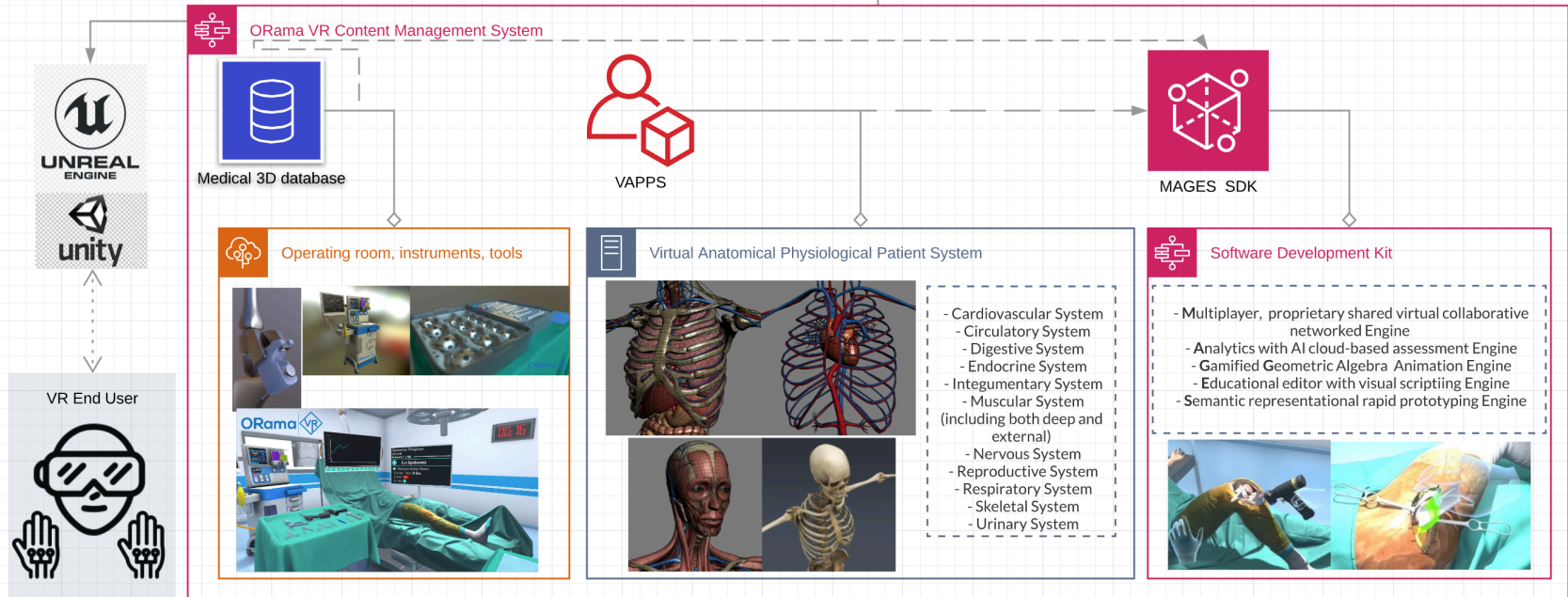
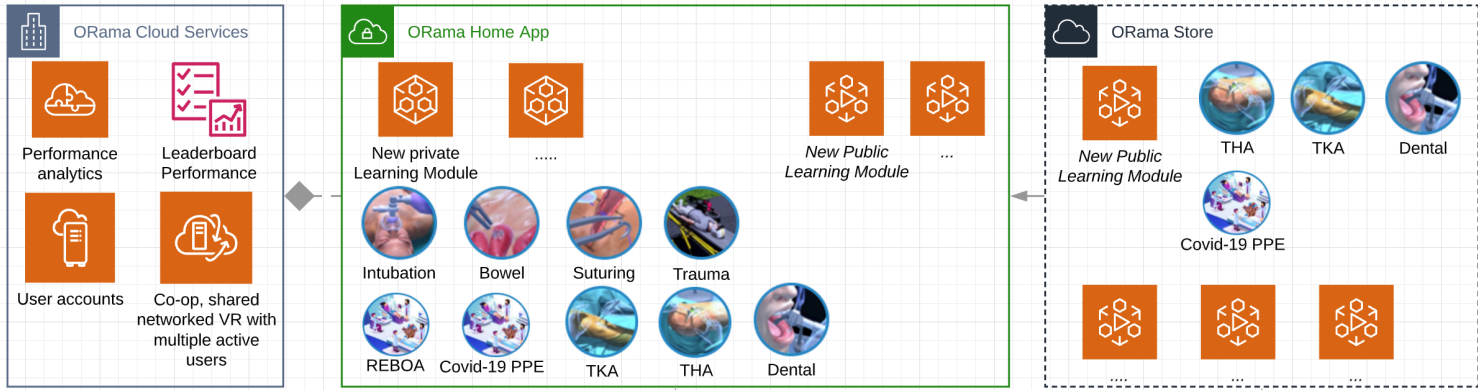
- Content developers need to be expert game engine programmers
- Difficulties in integration
- Duplication of application state
- Difficult code reuse and weak extension model



MAGES Platform SDK

- VR content creators don't have to be expert programmers
- curbing complexity
 - customisations, replacements, extensions
- rapid prototyping
 - cutting development time
- Massive code reuse & design reuse







MAGES Platform and Unity

ORama Cloud Services

- Co-op, shared networked VR with multiple active users
- Performance analytics
- User accounts

Unity Editor Integrated Development Environment (IDE)

MAGES SDK editor plugin

ORamaVR Platform

third-party tools/APIs/Plugins

- SteamVR
- Photon
- Oculus SDK
- Dissonance
- Wave SDK

MAGES SDK including user deployable Coop, analytics and user account management

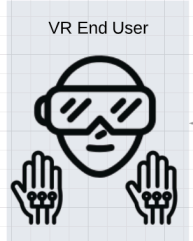
unity

Unity Engine and SDK

Operating systems

windows

Android



app

VR executable application (.exe or .apk) including Unity Runtime

VR Hardware

standalone, all-in-one VR HMDs

VR-ready PC

tethered VR HMDs

Multiplayer with Geometric Algebra Transformations

Multiplayer with Geometric Algebra Transformations



7+ Simultaneous users

- Dual Quaternion Interpolation engine
- Reducing network traffic
- Efficient and smooth transformation



Our SDK offers:

- Integrated DQ interpolation
- Build-in networking

Multiplayer with Geometric Algebra Transformations

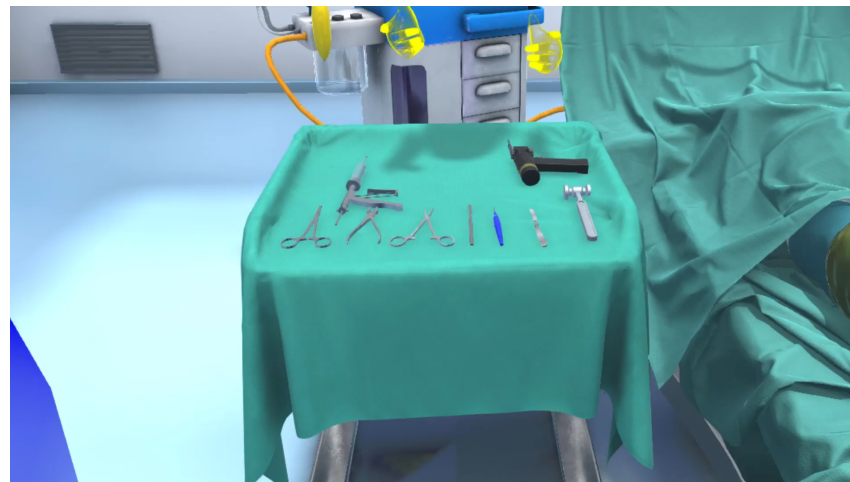


The OvidVR SDK can support more than 7 users operating the same in the same virtual environment. Due to our Dual Quaternion Interpolation engine network data transfer and CPU usage is reduced. Also, Dual Quaternions provide a smoother and more reliable interpolation between the transformation values.

Comparison of animation blending using different methods on a single character (Polygon count: 135.976).

<u>Method</u>	<u>Time (ms)</u>
Quaternions	0.0017
Dual Quaternions	0.0016
CGA-GPU (Quaternion Algebra)	0.0017
CGA-GPU (Inclusive Algorithm)	0.0022

Network send rate reduced from 30 to 20 times per second



How can I use multiplayer feature in OvidVR SDK? < >

The multiplayer feature is already integrated in the SDK. The only think required, is to press configure network prefabs and done.

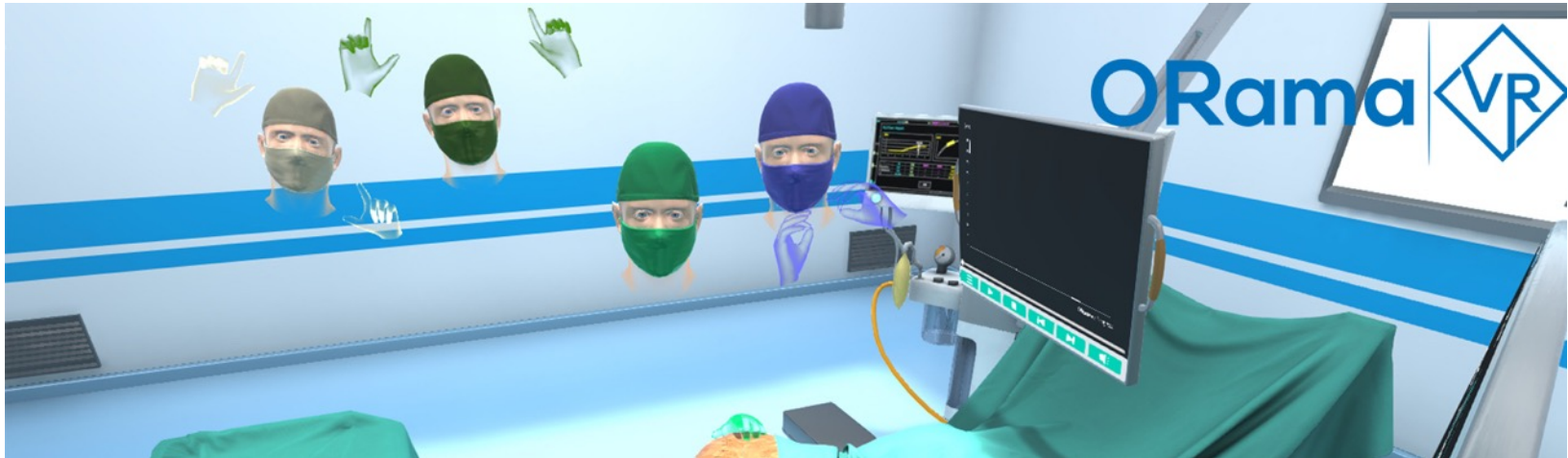
All the actions in the operation are automatic synchronized with our custom event messages.



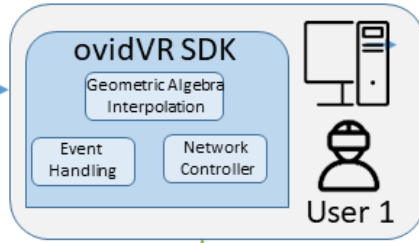
Cooperation level Architecture



- Our Multiplayer implementation is created on top of Unity's Networking layer.
- Geometric Algebra Transformations is based on **GLM mathematics** library as native dynamic library.
- Our SDK provides one line callbacks of GA interpolation via a C# managed integration.



Master Server



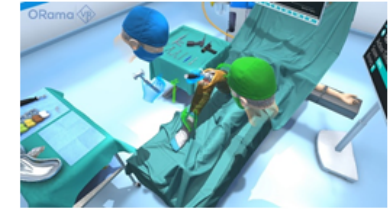
Server broadcasts
Position/Rotation of:
Avatars, VR objects

- Server receives
- Position/Rotation of shared VR assets
 - Trigger events
 - VR Avatars

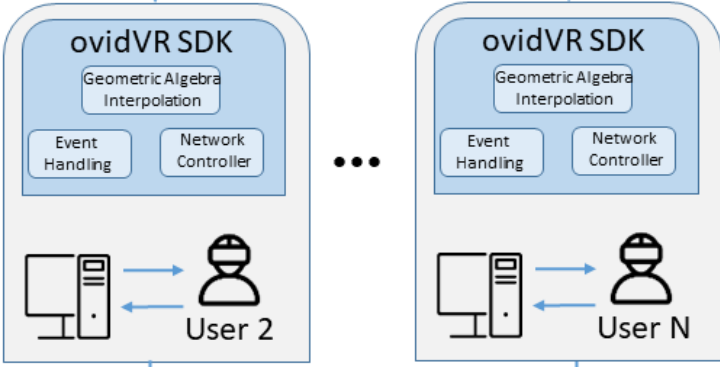
- Server broadcasts
- Synchronize Operation Steps
 - Handle Events
 - Broadcast messages to clients
 - Handles Authorities (Tools/assets)
 - Animation Synchronization



- Online Matchmaking
- Networking API



Clients



- Tethered/Untethered VR HMDs
- Remote Collaboration
- GA interpolation to broadcast less data
- h/w independence

ORamaVR networking layer

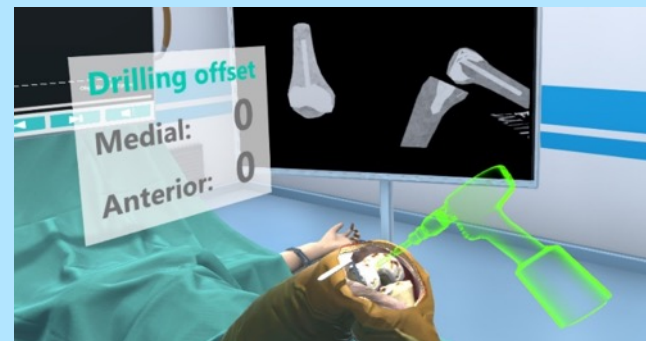
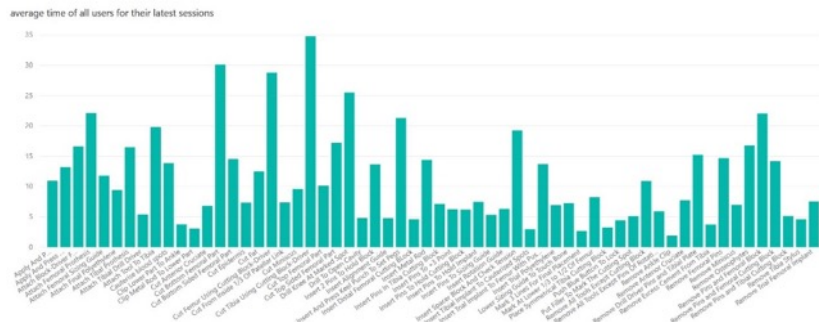
Analytics Engine

Analytics engine with cloud-based user assessment



Adaptive difficulty levels

- Tracking surgical skills
- Cloud-based user assessment
- Realtime error tracking



Select Difficulty: **Easy** ▾

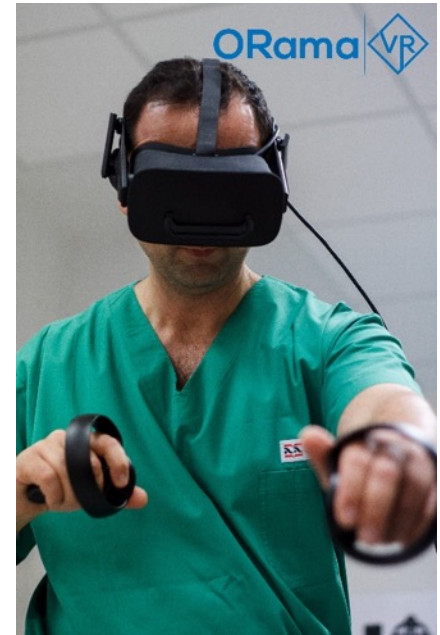
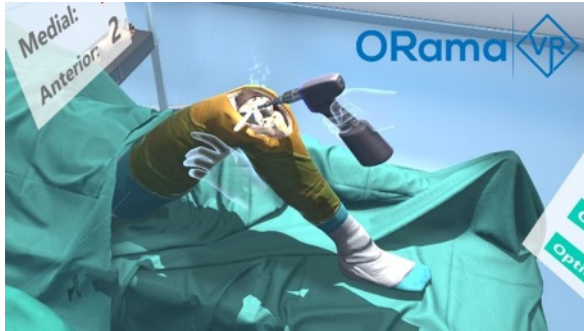
- Visual guides
- Critical errors
- Audio guide
- Normal errors
- Aided tool selection



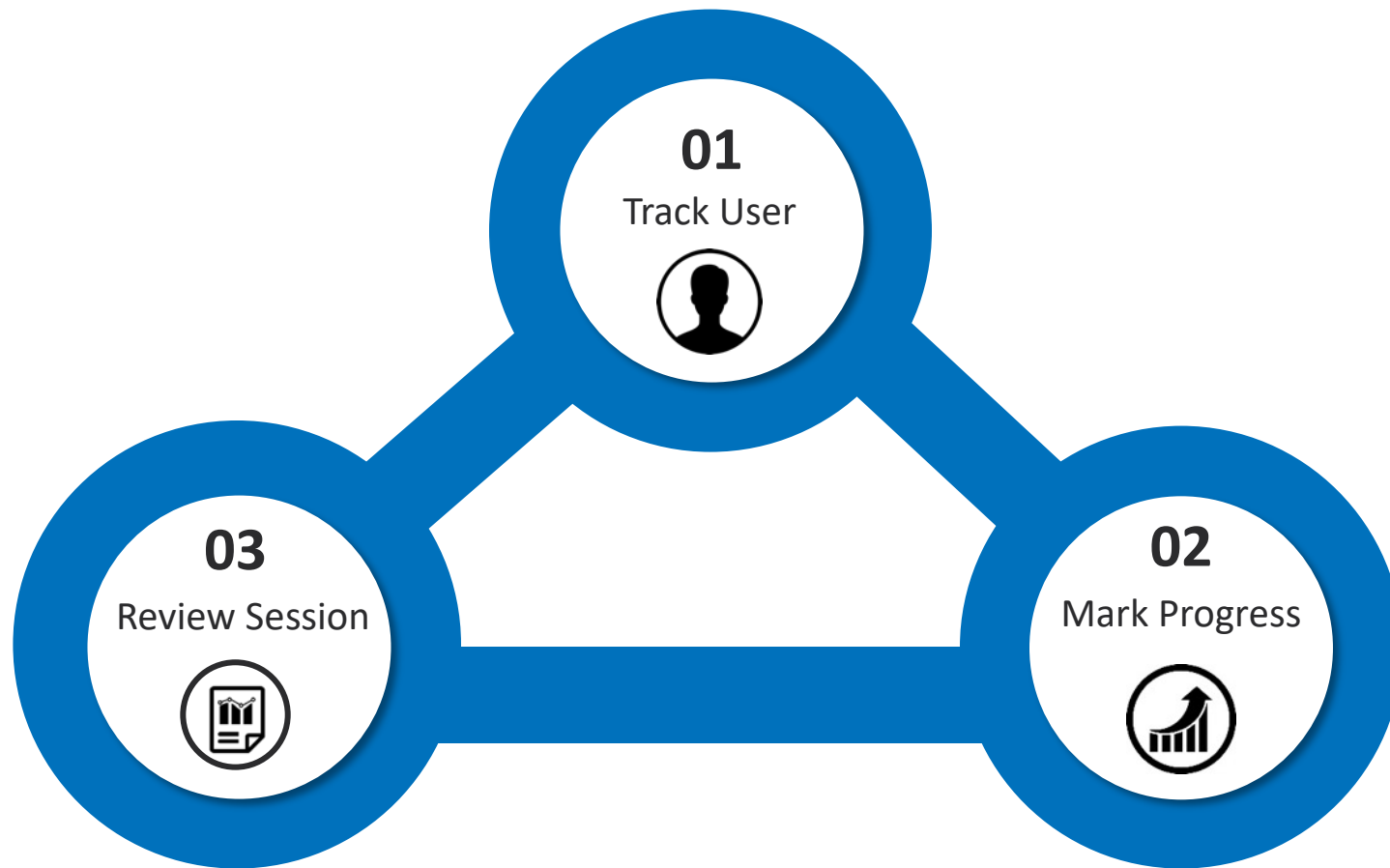
What is unique in our Analytics Engine?



- We track all user interactions
- We created our own point system algorithm
- Different difficulty levels – easy, medium, hard
- Detailed analytics report for user assessment
- Online platform for session preview



Summarizing the Analytics Engine function



Gamified Rapid Prototyping

Gamified rapid prototyping



- Everything required, ready out-of-the-box!

The OvidVR SDK provides everything essential for the creation of a new VR application without the need of any external plugins.

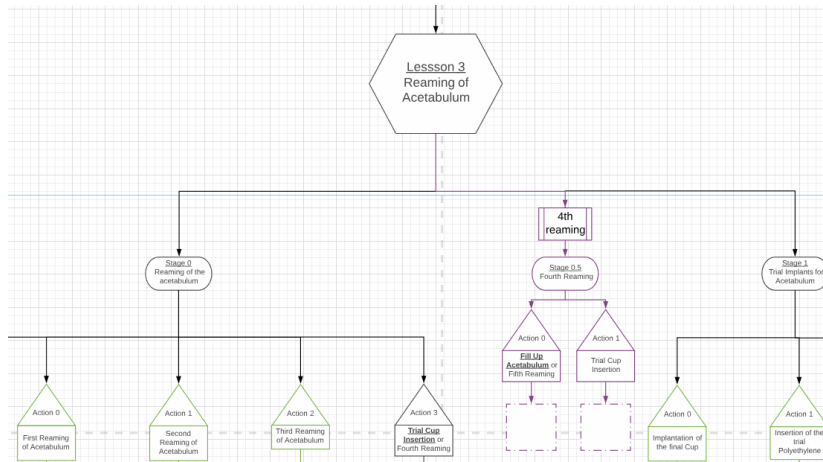
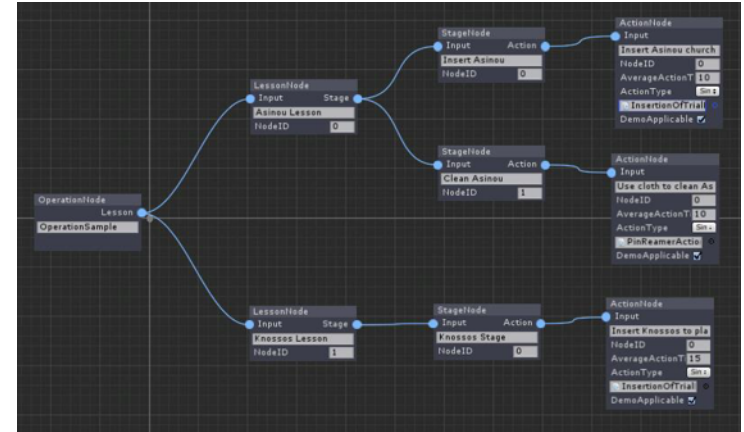
The only additional thing required from the developers, is the content!



Gamified rapid prototyping



- Visual Scripting Editor
 - Model, modify and generate through scriptable nodes to speed up production
 - Code-free, User-friendly
 - Extract and simplify complex application stages while remaining flexible
 - Assign distinctive functionalities with the use of multiple Action types

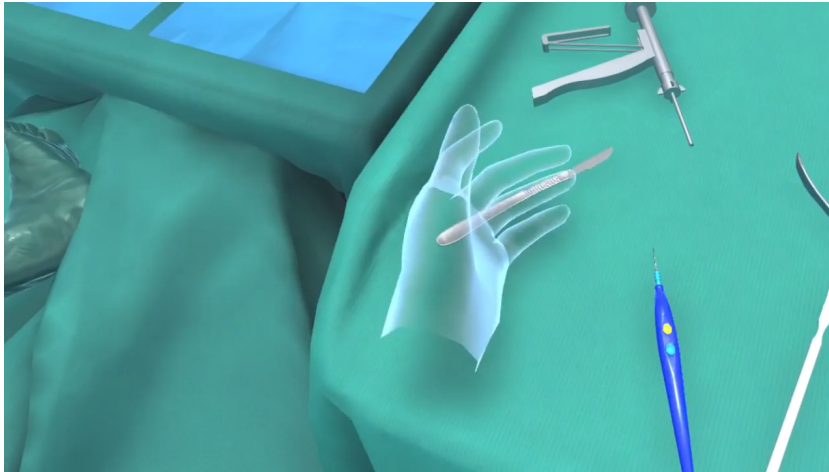
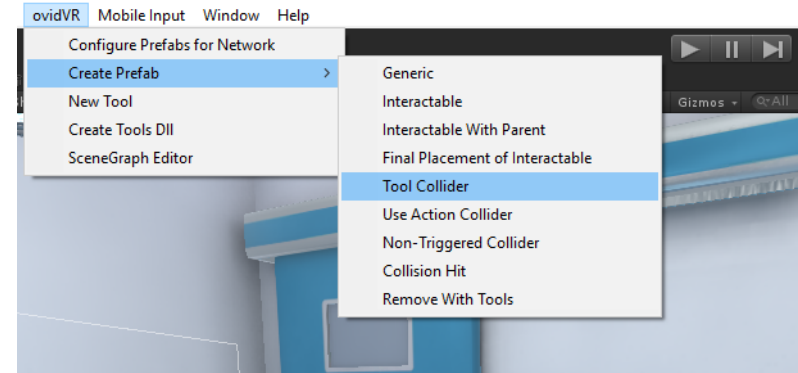


- Multiple Path Decision Making
 - Deviation from predetermine paths depending on user actions
 - Real time decision making
 - Easy implementation and path interchange with the use of the Visual Scripting Editor

Gamified rapid prototyping



- Multiple Tool Constructors for any type of Interaction
 - Physics Interaction (w or w/o parent)
 - Another/Multiple Tool Interaction
 - User Interaction (use / insert / remove)
 - Collision Hit
 - Precision Placement



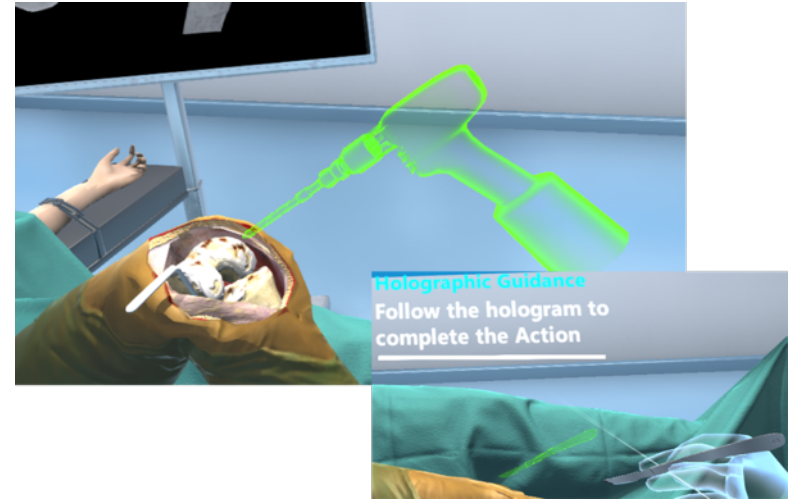
- Physical Interaction with Tools
 - Natural interaction between physical objects, obeying to the laws of physics
 - User-friendly tool interaction and selection
 - Easy implementation (single script addition to physical object)
 - Using ORamaVR's plug-in OvidVRPhysX

Gamified rapid prototyping



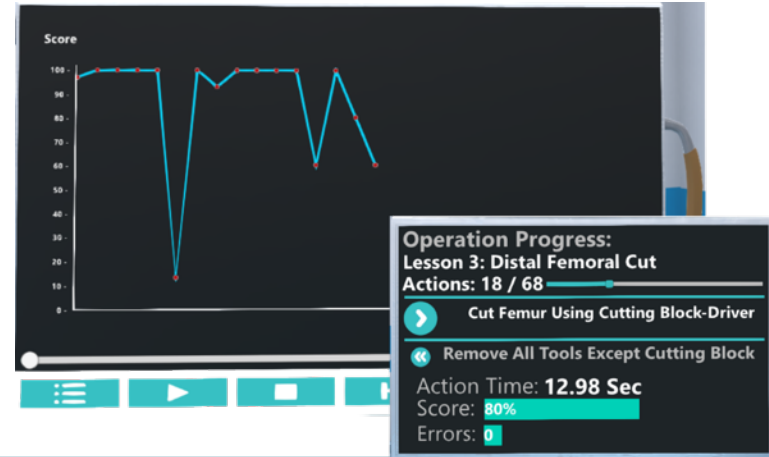
- Visual Aid

- Animating Holograms demonstrate the correct tool and its usage for the specific action
- Aidlines that provide additional information and spatial guidance
- Action visualization with a real time scoring system. Supports per action score and total score displayed in a normalized graph



- Scoring System

- Automatically calculated after each Action completion
- Monitor user activity and display both score and errors
- Interactive Graph displaying per Stage scores
- Created inside Unity using C# and ORamaVR's native plug-ins

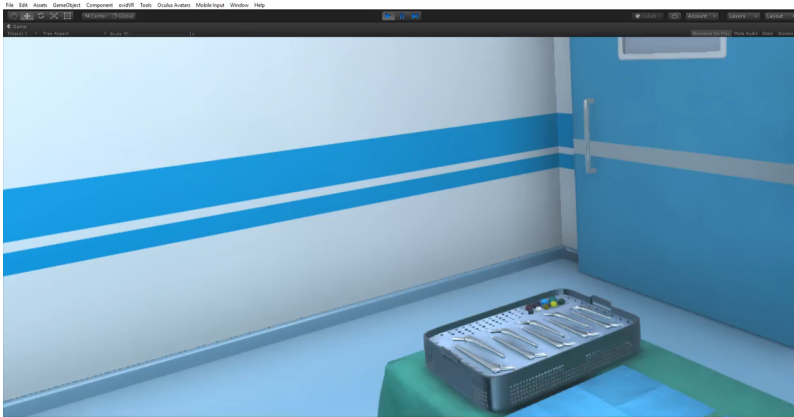
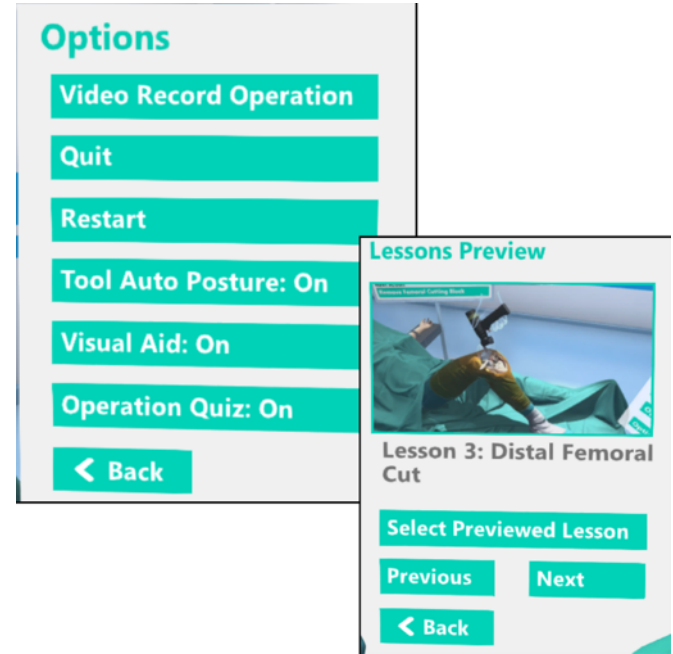


Gamified rapid prototyping



- UI

- User-friendly
- VR focused design
- Developer simplicity regarding UI creation and usage:
 - Simple template with primary/secondary titles
 - Button list with unlimited button configuration.
 - Drag & Drop features for any type of button functionalities
 - License Affected buttons
 - Works out-of-the-box with the Action Prototype Mechanism



- Second Generation UI
 - Beta phase

OvidVR Device Integrations



OvidVR GameController is a dynamic plug-in, implemented to support all VR/AR devices.

The SDK already contains implementations for HTC Vive, Oculus SDK, Mixed Reality Headsets and SteamVR .

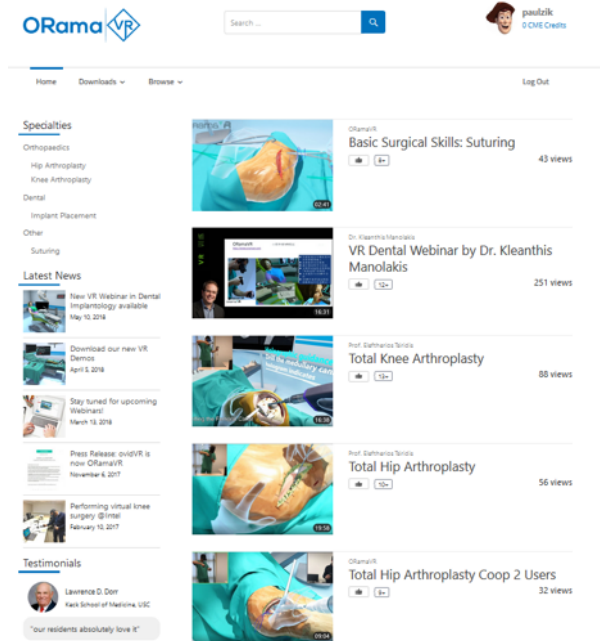


Educational Curriculum

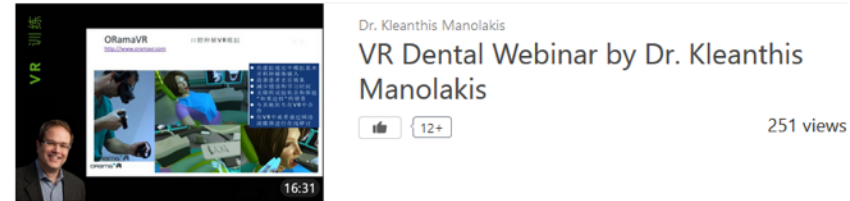
Educational Curriculum



- Training and Education
- Define the medical objectives for each operation
- Realtime user questionnaire



- Live webinar support



Educational Curriculum



Training refers to the acquisition of skills whereas **Education** refers to the acquisition of knowledge and information.

Training

- Using our analytic system we track the training progress of participant
- Transfer skills and knowledge from VR to the operating room
- Adaptive difficulty levels according to user's experience

Education

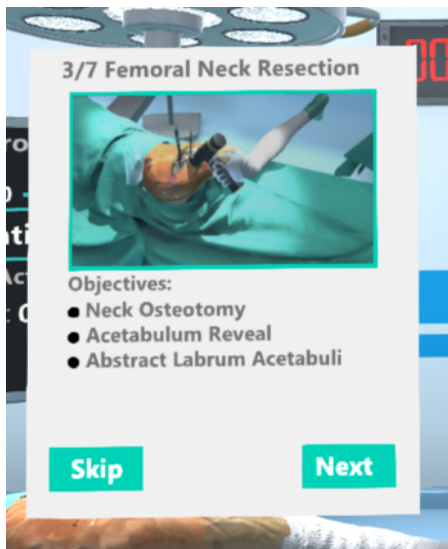
- Our SDK offers the tools for curriculum based customization
- Surgical step prioritization
- Webinars, user questioners and our e-learn visualization platform enhances the educational aspect



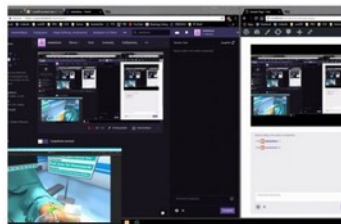
Educational Curriculum: Mechanics & Novelties



We provide **all the essential components** to generate educational processes with respect to a defined curriculum.



- Our **elearn** site integrates a multimodal platform suitable for account management and educational enhancement.
- We provide an embedded livestream system (using Twitch) to run webinars online.
- Live Q&A is possible with our custom communication system between the users of elearn and the VR participants.



ORamaVR
Total Hip Arthroplasty Live Demo –
Twitch



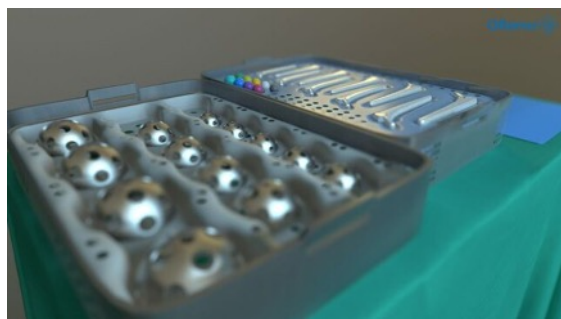
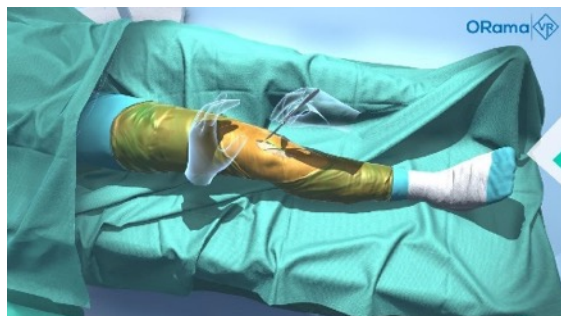
313 views

Semantic representation of medical applications

Semantic representation of medical applications



- Rapid operation adaptation to variations
- Medical Step Customization

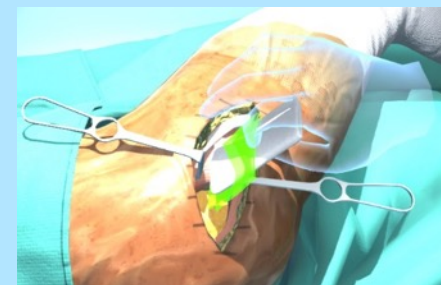


Action Prototypes as s/w patterns

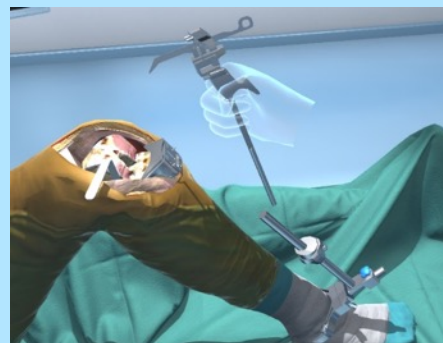
Insert Action



Use Action



Remove Action



Tool Action



Scenegraph Architecture

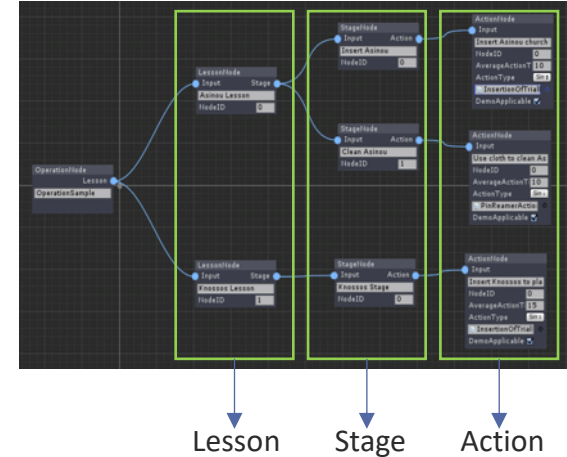


Our **Scenegraph** architecture transforms any educational pipeline into a **procedural graph**

Each educational process consists of several nodes in a specific hierarchy with 3 levels of abstraction:

1. Lesson
2. Stage
3. Action

These nodes populate the Scenegraph (LSA graph)



```
<Lessons>
<Lesson_Name>Knossos Lesson</Lesson_Name>
<Stages>
<Stage_Name>Knossos Assemble Stage</Stage_Name>
<Actions>
<Action>Remove the flashing Minoan Jar</Action>
<ActionClassName>RemoveJarExample</ActionClassName>
<ActionType>Simple</ActionType>
<AverageActionTime>10</AverageActionTime>
<IsDemoApplicable>y</IsDemoApplicable>
</Actions>
<Actions>
<Action>Remove the Minoan Jars using Pliers</Action>
<ActionClassName>RemoveJarWithToolExample</ActionClassName>
<ActionType>Simple</ActionType>
<AverageActionTime>10</AverageActionTime>
<IsDemoApplicable>y</IsDemoApplicable>
</Actions>
</Stages>
</Lessons>
```

We offer:

- Scenegraph visual scripting editor
- Different types of Nodes to fit every case
- Realtime decision making (Alternative Path) that updates the LSA graph according to user's actions

Action Prototypes as s/w patterns



Define each medical step with one or more **Prototypes**

Prototype \equiv Medical module

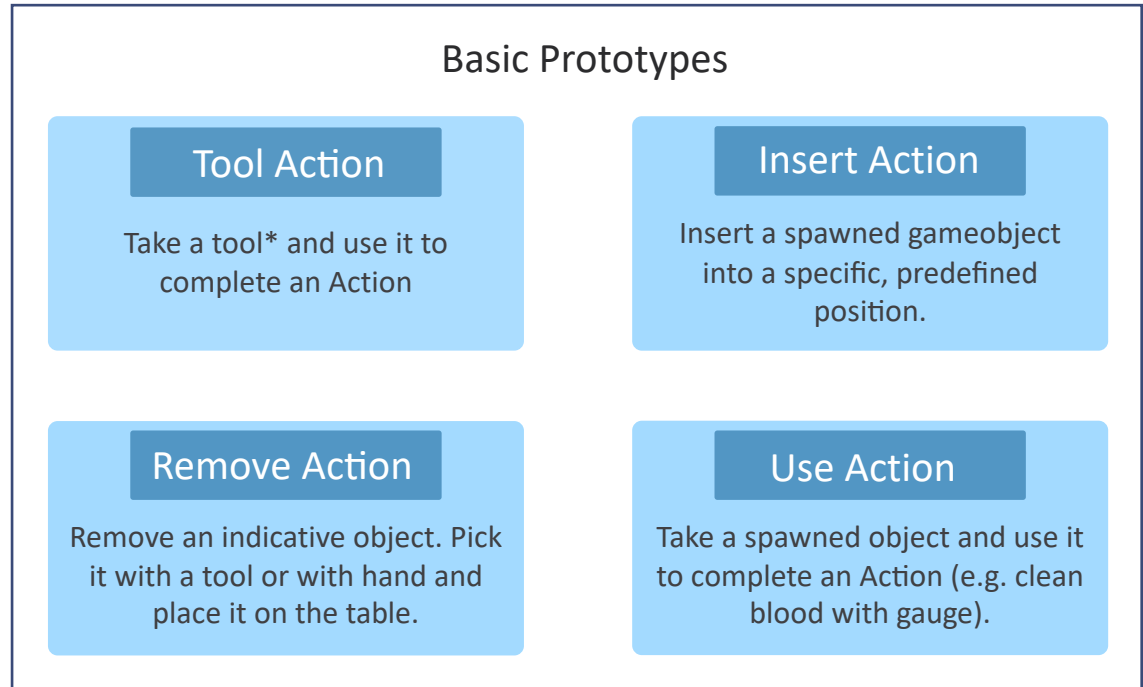
1. **Tool Action**
2. **Insert Action**
3. **Remove Action**
4. **Use Action**
5. Combined Action
6. Parallel Action

Combined Action:

Use two or more Basic Prototypes as modules to generate a complex Action

Parallel Action:

Two or more Actions (combined or basic) that run simultaneously.



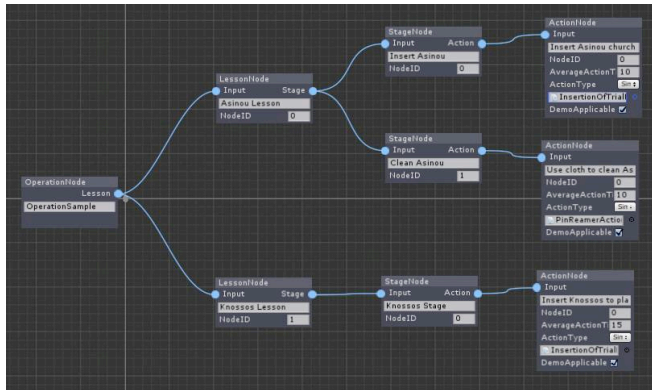
*Tool: A physical object (gameobject) which always remain on scene and has specific functionalities and behaviors. (e.g. scalpel, mallet)

Architectural Novelties



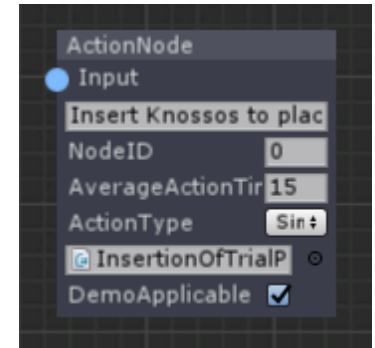
Scenegraph

- Modular architecture for **any** educational approach.
- Easy **customization** and **maintenance**.
- Visual representation of complex pipelines.



Action Prototypes

- Significant reduction of programming needs.
- Increases the levels of **abstraction** for each step.
- **Reusable** and **scalable** solution to produce complete operations.

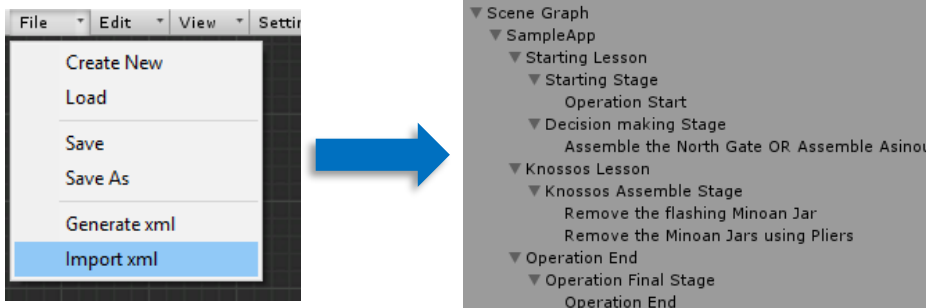


Semantic representation in detail



Scenegrph consists of **nodes** that represent each step

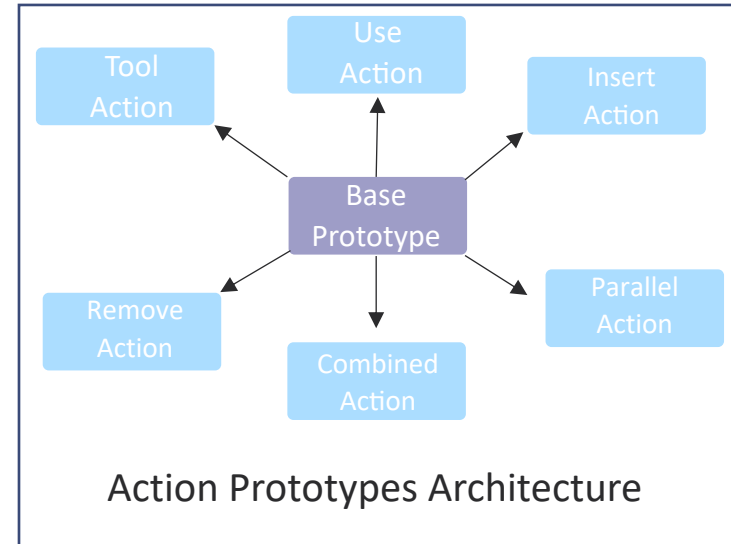
- LSA Nodes are generated from our custom Scenegrph editor.



- We integrated our system to run with gameObjects for realtime visualization and flexibility.

Each step of an educational process is translated to an Action Script

- Action scripts are implemented in a way to support as many cases as possible.



Licence System

Embedded license system

- Online account creation
- Support multiple account types (demo, free, professional, unlimited)

id	Username	Product Name	License Type	Currently Active	Expiration Date	IP	Login Time	Heartbeat	Logout Time	30 Days Activity
1	[redacted]	HomeApp	unlimited	INACTIVE	11-Mar-19 11:07:00 AM	[redacted]	30-Jul-18 7:50:38 AM	30-Jul-18 7:50:39 AM	30-Jul-18 7:50:43 AM	OK
2	[redacted]	TKA	unlimited	INACTIVE	11-Mar-19 11:45:00 AM	[redacted]	10-Jul-18 10:35:00 AM	10-Jul-18 10:35:00 AM	10-Jul-18 10:35:00 AM	OK
3	[redacted]	THA	unlimited	INACTIVE	11-Mar-19 11:46:00 AM	[redacted]	23-Jul-18 7:54:47 AM	23-Jul-18 7:54:47 AM	23-Jul-18 7:54:53 AM	OK
5	[redacted]	HomeApp	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF
6	[redacted]	TKA	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF
7	[redacted]	THA	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF
11	[redacted]	HomeApp	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF
12	[redacted]	TKA	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF
13	[redacted]	THA	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF
14	[redacted]	HomeApp	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	24-Apr-18 12:25:14 PM	24-Apr-18 12:29:55 PM	24-Apr-18 12:29:57 PM	OFF
15	[redacted]	TKA	demo	INACTIVE	14-Mar-19 10:05:41 AM	[redacted]	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	19-Mar-18 10:05:41 AM	OFF



- Online account management
- Online account reports
- Hosted in MS Azure Platform

Backend license implementation

Create your own product

Create Product

Product Name
Test Product

Product Image
image.png

Image Preview

ORama VR

Default License
demo

Create Product

name, image, default license

Register your users

Create your account

Hospital / Organization Your Country

Select Specialty

First Name Last Name

Username

E-mail Address

Password

Password

By clicking "Create Account" you agree to our Terms & Conditions and Privacy Policy

Create Account

use our form, or create you own

Manage licenses

Edit License

Username
bach

Product Name
HomeApp

License Type
unlimited

Currently Active
false

Expiration Date
2019-03-11

Time
11:07

IP
139.91.207.18

Login Date
2018-07-30

Time
07:50

Heartbeat Date
2018-07-30

Time
07:50

Logout Date
2018-07-30

Time
07:50

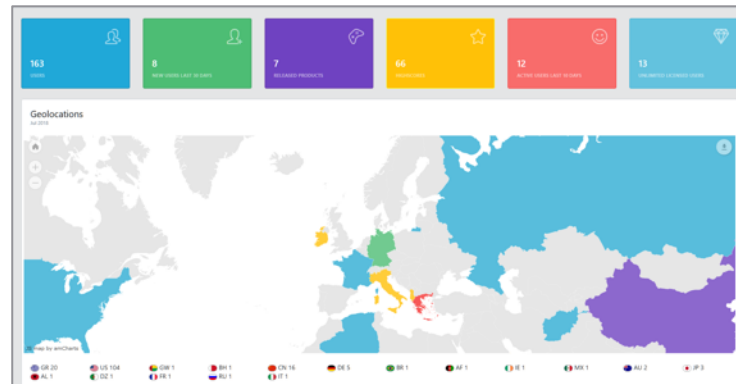
Delete!

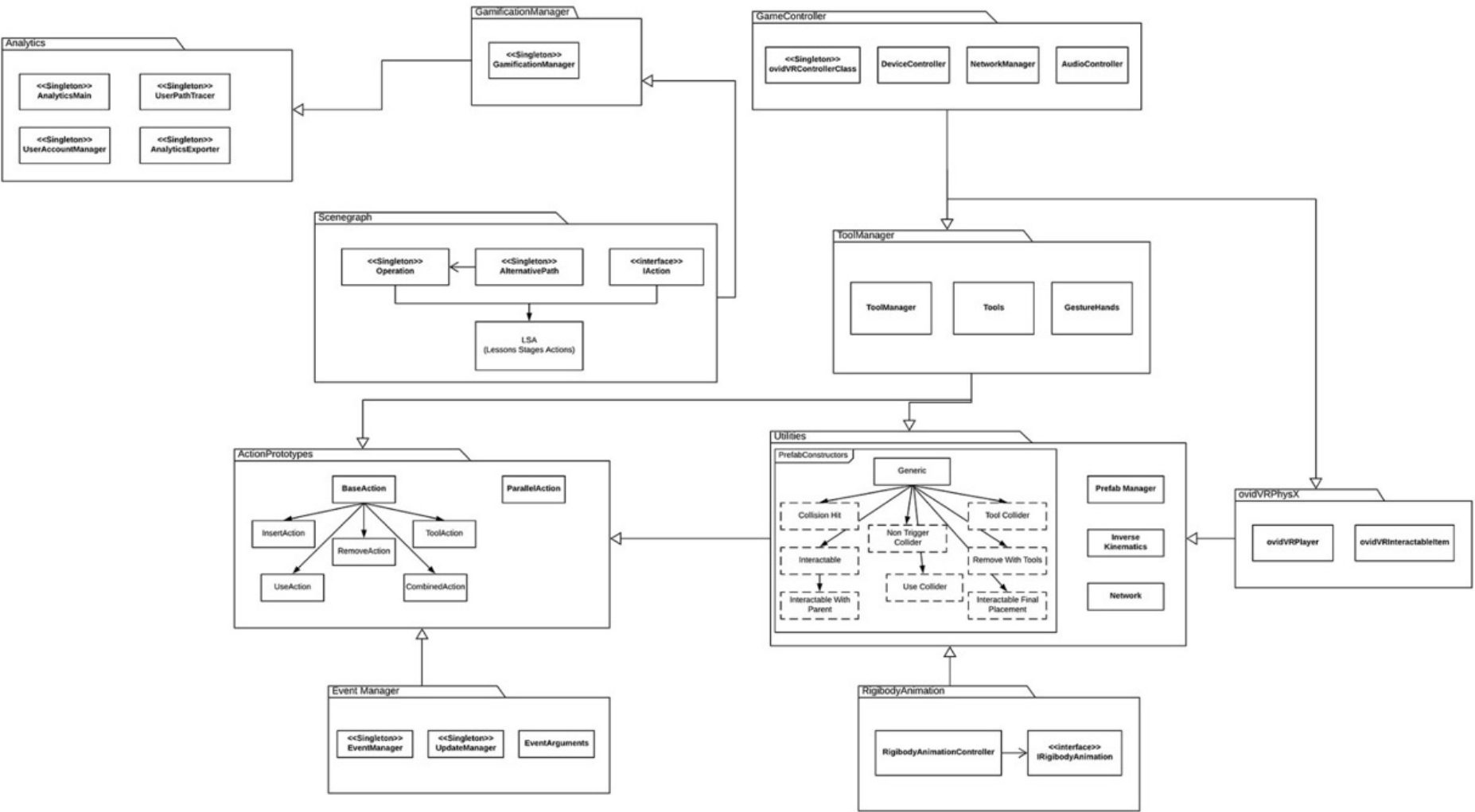
Save changes

edit, create, delete

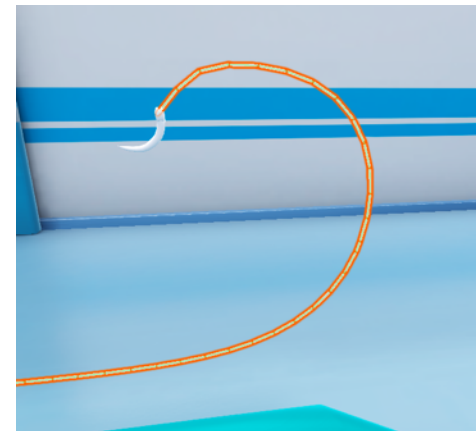
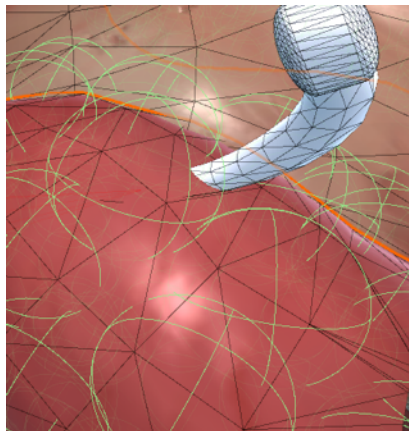
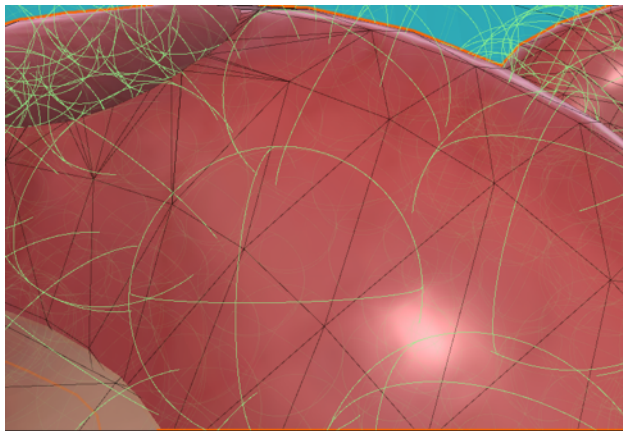
View Traffic

Real-time product usage
Real-time user traffic
Real-time statistics



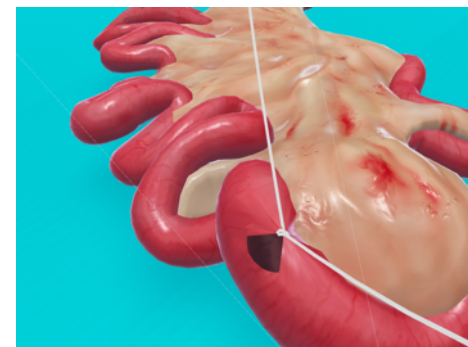


Proprietary physics-based Rigid and deformable object interaction



To enable **soft body physics simulation** for **any 3D model**, a **proprietary clustering** of the model's vertices is applied.

- enables faster calculation for the soft body simulation
- don't have to calculate the result of the simulation for each vertex but only the result for the cluster
- custom physically-based methods for its update:
 - *cutting, tearing, penetration, deformation, separation, unifying, knots, suturing under*



ORama



<http://www.oramavr.com>
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