PA199
Advanced Game Design

Lecture 2

Serious Games and Virtual Environments

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Assignment

Assignment - Task

- Title
  - Develop from scratch an interactive 3D game
- Task
  - The aim of the assignment is two fold: (a) develop a small game engine in C++ and (b) develop the graphics and physics components for an interactive 3D game
    - These components should that cover the general motion of a rigid body in three dimensional space, including issues of collision of bodies and their subsequent motion

Game Engine - Task

- The aim of the game engine component is to implement from scratch a set of computer graphics classes that will be used for
  - Modelling the scene of the game
  - Creating the physics components of different interactive computer games

Game Engine - Specification

- Based on the vector theory you should implement a 3D vector class in C++ which will be used as a basis for the rest of the course
- Based on the matrices theory you should implement a 3×3 matrix class in C++ which will be used as a basis for the rest of the course
- Finally you should implement a ray class in C++

Game Engine - Minimum Implementation

- The basic implementation should include the following:
  - A 3D vector class, which you can call TVector, with three components (x, y and z)
  - A 3×3 matrix class, which you can call Tmatrix, with a two-dimensional array (i.e. double _Mx[3][3])
  - A Ray class which will be based on the vector and matrix class

Game Engine - Minimum Functionality

- Unit vector (for vector class)
- Magnitude of a vector (for vector class)
- Invert a vector (for vector class)
- Add two vectors (for vector class)
- Subtract two vectors (for vector class)
- Dot product vector (for vector class)
- Cross product vector (for vector class)
- Addition (for matrix class)
- Subtraction (for matrix class)
- Multiplication (for matrix class)
- Transpose (for matrix class)
- Inverse (for matrix class)
- Calculate distance between two rays (for ray class)
- Calculate distance between a ray and a point (for ray class)

Game Engine - Extra Features

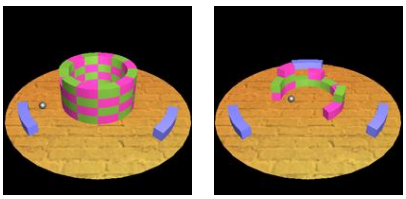
- Extra credit will be given for adding more features to the classes
  - i.e. More mathematical libraries such as 4x4 class

Game Specification

- The traditional 2D Breakout is one of the first interactive video games available on personal computers
- The main idea is to knock down a set of 2D bricks using a 2D racket and a ball moving at constant speed
- As soon as the ball collides with a brick then it vanishes
- The goal of the game is to make all bricks disappear from the game arena
- To increase the level of difficulty and game-play, later versions make use of multiple rackets and balls and vary the speed of the ball

Game Specification .

- The 3D Breakout, a cylindrical wall that consists of 3D bricks, exists in the middle of the simulation area



Game Specification ..

- A single player controls three curved bats, each positioned at an angle of 120 degrees to each other
- The bats can move clockwise or anticlockwise using the keyboard arrow keys as input
- The cylindrical wall is situated in the middle of the circle and is constructed by twelve bricks in such a way that it looks like a shaft
- The main idea of the 3D game is to knock down all the 3D bricks and 'destroy' the well

Game - Graphics Minimum Implementation

- Colour
  - Bats, Ball and Bricks of the well
- Manipulate the scene
  - Rotate, translate and scale
- Change camera positions
  - Perspective view, top view and ball view
- Transparency
  - Bats and bricks of the well
- Add lighting to the game
  - Ambient light, diffuse light and specular light
- Record the score
- Texturing
  - Ground

Game - Graphics Extra Features

- Appropriate gaming scenario
- Logo introduction page
- Increase/decrease the speed of the ball
- Use of textures to the bricks and bats
- Add sound
- Special effects

Game - Physics Minimum Implementation

- Construct from scratch a gaming environment
  - Three bats
  - One well
  - A ground
  - One ball
- A real-time simulation of a ball
- Collision detection between:
  - Ball-bats
  - Ball-well
  - Ball-Invisible wall

Game - Physics Extra Features

- Extra credit will be given for adding more features to the game
- Some ideas for improvement include the following:
  - Friction
  - Weight
  - Make the ball bounce
  - Gravity
  - Deformations

Report Structure

- Title page
- Contents
- Abstract (or summary)
- Introduction
- Background theory
- Methodology and results
- Conclusions
- References
- Appendices

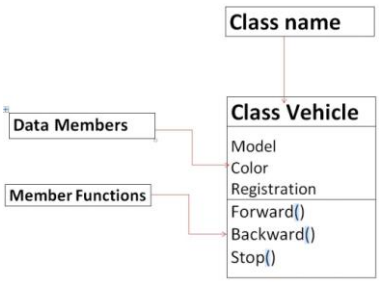
http://libweb.surrey.ac.uk/library/skills/writing%20skills%20Leicester/page_76.htm

What About Programming?

- You are expected to know how to program but not be a guru
- More emphasis is given in the algorithms and not in the programming skills
  - Which are easy to acquire
- C++ will be the main programming environment
- OpenGL will be used as the main graphics API

Basic OO Style is Required

- Focus is NOT in programming skills!



Serious Games

Essential Game Elements

- Huizinga (1950)
  - Free activity, outside "ordinary" life, not "serious"
  - Absorbs the player
  - No material interest or profit
  - Distinct Boundaries of time and space
- Caillois (1961)
  - Free (voluntary), separate (time and space)
  - uncertain, unproductive, governed by rules, make-believe
- Salen and Zimmerman (2003)
  - A system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome

Serious Games - A Definition

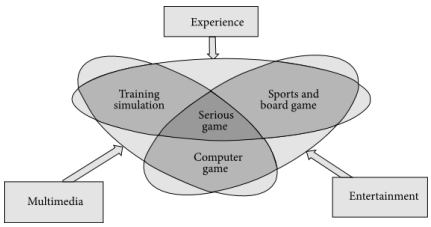
- Describes computer games that are not limited to the aim of providing entertainment that allow for collaborative use of 2D/3D spaces but are also used for different purposes in a number of application domains

Anderson, E.F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., de Freitas, S. Developing serious games for cultural heritage: a state-of-the-art review, Virtual Reality, Springer, 14(4): 255-275, 2010. (ISSN: 1359-4338)

Serious Games - Another Definition

- Bergeron, (2006): "a serious game is an interactive computer application, with or without a significant hardware component, that: has a challenging goal, is fun to play and/or engaging, incorporates some concept of scoring, and imparts to the user a skill, knowledge, or attitude that can be applied in the real world." (pg. xvii)

And Another Definition



Laamarti, F., Eid, M., El Saddik, A. An Overview of Serious Games, International Journal of Computer Games Technology, Article ID 358152, 2014.

Milestones in the History of SG

Year	Serious game	Application
1970	Serious Games book by C. Abt	Academic book
1972	Magnavox Odyssey	Education
1973	The Oregon Trail	Education
1980	BattleZone	Training
1981	The Bradley Trainer	Training
1982/1983	Pole Position/Atari VCS 2600 console	Training
1996	Marine Doom	Military
2002	America's Army	Military
2003	DARWARS	Military
2005	VBS1	Military
2006	BiLAT	Interpersonal communication
2009	VBS2/Game After Ambush	Military
2012	X-Plane 10	Training

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Advantages of Games

- Motivation/Engagement
- Interactivity
- Mechanic is the Learning
  - To beat the game is to learn the message/skill
  - But only when done right, very difficult
  - Beyond content to problem solving/systems learning
- Adaptive to the Learner
- Real-Time Assessment
  - Analytics/Data/Log Files

Simulations and Games

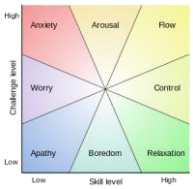
- Squire (2003) examples of uses:
  - Manipulate otherwise unalterable variables
  - Enable students to view phenomena from new perspectives
  - Observe systems behavior over time
  - Pose hypothetical questions to a system
  - Visualize a system in three dimensions
  - Compare simulations with their understanding of the system

Goals of Serious Games

- Flow (Csikszentmihalyi)
  - Balancing challenge
    - See next slides
- Scaffolding
- "Transfer" Knowledge
- System Understanding
- Attitude/behavior change

FLOW

- FLOW is the mental state of operation in which a person performing an activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of the activity
  - Characterized by complete absorption in what one does



Mental state in terms of challenge level and skill level, according to Csikszentmihalyi's flow model

https://en.wikipedia.org/wiki/Flow_(psychology)

FLOW Components

- Six factors are encompassing a FLOW experience:
  - Intense and focused concentration on the present moment
  - Merging of action and awareness
  - A loss of reflective self-consciousness
  - A sense of personal control or agency over the situation or activity
  - A distortion of temporal experience, one's subjective experience of time is altered
  - Experience of the activity as intrinsically rewarding, also referred to as autotelic experience

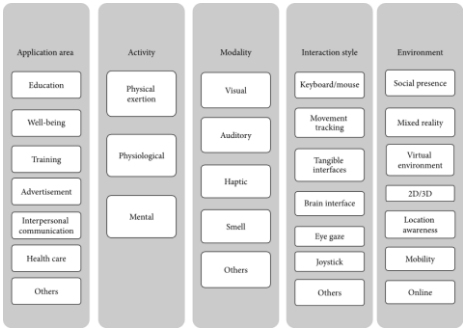
https://en.wikipedia.org/wiki/Flow_(psychology)

Serious Games Taxonomy

Serious Games Taxonomy
by Ben Sawyer, President, Digital Mill

SECTOR	GENRE						
	Games for Health	Advergames	Games for Training	Games for Education	Games for Science & Research	Production	Games as Work
Government & NGO	Public Health Education & Mass Casualty Response	Political Games	Employee Training	Inform Public	Data Collection/ Planning	Strategic & Policy Planning	Public Diplomacy, Opinion Research
Defense	Rehab & Wellness	Recruitment & Propaganda	Soldier Support Training	School House Education	War Games & Planning	War planning & weapons research	Command & Control
Healthcare	Cybertherapy/ Exergaming	Public Health Policy & Social Awareness Campaigns	Training Games for Health Professionals	Games for Patient	Visualization/ Epidemiology	Biotech manufacturing & design	Public Health Response Planning & Logistics
Marketing & Communications	Advertising Treatment	Advertising, Marketing with games, product placement	Product Use	Product Information	Opinion Research	Machinima	Opinion Research
Education	Inform about disease/ risks	Social issue games	Train teachers/ Train workforce skills	Learning	Corporate Science & Recruitment	Documentary?	Teaching Distance Learning
Corporate	Employee Health Information & Wellness	Customer Education & Awareness	Employee Training	Continuing Education & Certification	Advertising/ Visualization	Strategic Planning	Command & Control
Industry	Occupational Safety	Sales & Recruitment	Employee Training	Workforce Education	Process, Optimization, Simulation	Nano/Bio-Tech Design	Command & Control

Another Taxonomy



Laamarti, F., Eid, M., El Saddik, A. An Overview of Serious Games, International Journal of Computer Games Technology, Article ID 358152, 2014.

Prensky's Classification

Content	Learning activities	Possible Game Styles
Facts	Questions, memorization	Game show, competitions
Skills	Imitation, coaching, practice	Role-play, adventure
Judgment	Reviewing cases, asking questions, making choices	Role play, strategy
Behaviours	Imitation, feedback, practice	Role playing games
Theories	Logic, experiment, questioning	Simulation, game creation
Reasoning	Problems, examples	Puzzles
Process	Analysis, deconstruction, practice	Strategy, adventure
Procedures	Imitation, practice	Timed, reflex games
Creativity	Play	Puzzles, invention games
Language	Imitation, practice, immersion	Role play, reflex games
Systems	principles, tasks, simulation	Simulation games
Observation	Observing, feedback	Concentration, adventure
Communication	Imitation, practice	Role playing, reflex games

More Than Just Games

- A trend towards the development of more complex, serious games, which are informed by both pedagogical and game-like, fun elements
  - Application area of game engines and online virtual environments

Early Example of Serious Games

Serious Games Forms

- Serious games can exist in the form of:
  - Simple web-based solutions
  - Online virtual environments
  - More complex 'mashup' applications
  - 'Grown-up' computer games
  - Mixed reality games
  - Mobile applications

Typical Example

Serious Games State-of-the-Art

- The state-of-the-art in Serious Game technology is identical to the state-of-the-art in Entertainment Games technology
  - They share the same technical infrastructure

Serious Games Uses

- Learning & Education
- Health Sciences
- Advertising
- Training
- Science and Research
- Art/Statement
- Journalism

Serious Games Strengths

- The main strengths could be generalised as being in the areas of:
  - Communication
  - Visual expression of information
  - Collaboration mechanisms
  - Interactivity
  - Entertainment

Requirements Gathering

- Need to work with Subject Matter Experts (SME's) to define learning/training content versus simply creating gameplay out of thin air
  - Game designers must work with instructional designers
  - Developers must effectively become SME's themselves

Challenges

- Access to SME's
- Access to environments
- Access to equipment
- Finding SME's fully knowledgeable in training content
- Creating SGs without simply creating a simulation

Serious Games Views

- Entertainment is more important!
  - While pedagogy is an implicit component of a SG it should be secondary to entertainment
- Education and pedagogy is more important!
  - Design methodologies for the development of games incorporating pedagogic elements

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Engagement / Fun

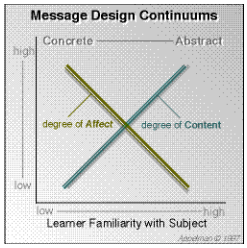
- … with what & why?
- In Traditional Teaching:
  - Engagement with Content is Primary
- In Entertainment Games:
  - Engagement with Tasks are Primary
- To a Professional Educator:
  - Learning is Predictable
- To a Professional Game Developer:
  - Fun is Predictable

Serious Game Design

- The Context and Needs determine objectives
- The Learning Objectives need to be stated
- The Player Motivation needs to be defined
- The Ideal Learning Environment for this context, objectives, and desired outcomes must be defined
- The Learning Environment must dictate % game play and % authentic simulation

Affective/Cognitive Balance

- Affective presentation (game) effective when content knowledge is low and content density is also low
- As content knowledge goes up then content density may rise but authenticity and functionality (Sim) must also rise



The Player Experience

- Cognition – changes in cognitive and affective domains
- Metacognition –all that the player is aware of including:
  - vision, audio, olfactory, kinesthetic, and haptic senses, plus an awareness of time, objects, & content
- Choice – perception of:
  - degree of control, and access to variables and information during game play
- Action – perception that they can do things such as:
  - interact with objects and elements within the game, have control of objects, elements, and own identity, have mobility to move through the environment, manipulate control interface to effect change

Game Structure

- Content
  - The story, the context, the amount of information available, the degree of concreteness or abstraction of the content, the authenticity, and its variability
- Environment
  - The virtual spaces and boundaries, the objects within these spaces and their functionality capabilities, plus any time limits imposed by the game
- Affordances
  - The abilities made for the player to change, manipulate, the objects, information, environment, their identity & capabilities, and/or to seek alternative information

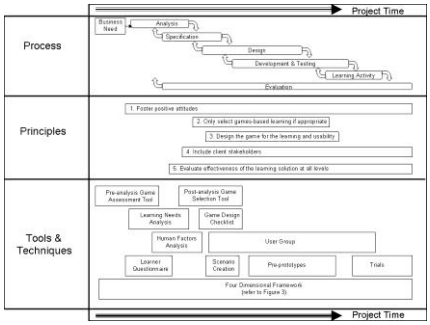
Experiential Mode Triage

Four Dimensional Framework

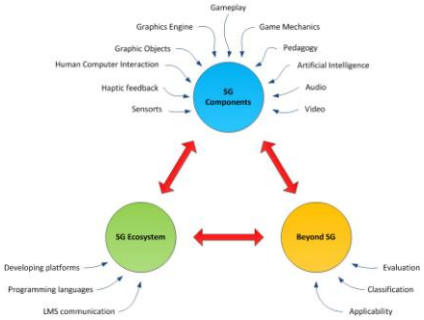
Four Dimensional Framework	
Learner Specifics	**Pedagogy**
Profile	Associative
Role	Cognitive
Competencies	Social/Situative
Representation	**Context**
Fidelity	Environment
Interactivity	Access to learning
Immersion	Supporting resources

Four elements that can be used as design and evaluation criteria for the creation of serious games

Exploratory Game-Based Learning Model

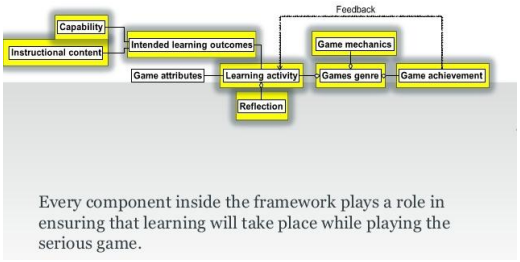


Serious Games Multidimensional Interoperability Framework



http://seriousgamessociety.org/index.php/2014-07-11-14-15-51/explore/134-media/388-serious-game-interoperability-the-good-the-better-a-the-optimal

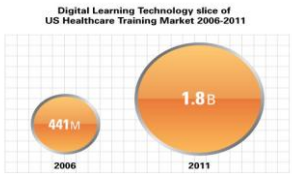
Conceptual Framework



Every component inside the framework plays a role in ensuring that learning will take place while playing the serious game.

http://www.slideshare.net/AmrYusoff/vsgames2010-v3

Serious Games Markets

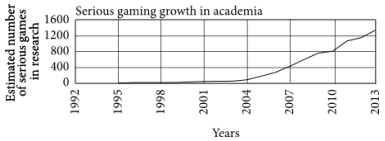


2007 Self-Paced E-Learning: $13.6 Billion
5-year annual growth rate: 22%

2006 Real-Time Collaboration-Based Learning: $2.6 Billion
5-year annual growth rate: almost 35%

Real-time Collaboration-based Learning is fastest growing learning technology in US

Academic Impact



Serious games growth in the research field based on surveyed papers in ACM digital library and IEEE Xplore

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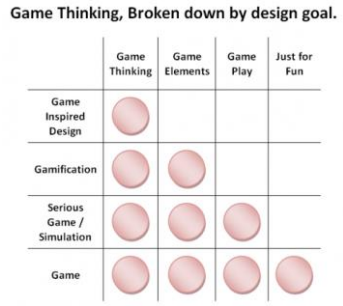
Gamification

- Gamification is the application of game-design elements and game principles in non-game contexts
- Gamification commonly employs:
  - Game design elements
  - Organizational productivity
  - Flow
  - Learning
  - Employee recruitment and evaluation
  - Ease of use and usefulness of systems
  - Physical exercise
  - Etc

https://en.wikipedia.org/wiki/Gamification

Gamification vs Serious Games



http://www.gamified.uk/gamification-framework/differences-between-gamification-and-games/

Case Studies

Serious Games in Health

Triage Trainer
TruSim, TSB, VEGA Group, Birmingham, SGI

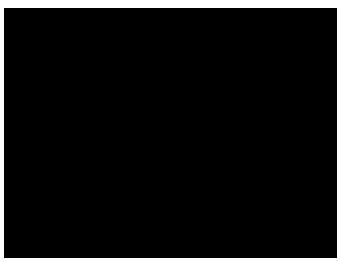
Preview
St Georges, JISC, SGI

Second Health
NPL, Imperial, SGI

NanoMedicine
Playgen, SGI

http://www.seriousgamesinstitute.co.uk/

NanoMedicine Video



Triage Trainer Case Study

- The game is set at the scene of an explosion in a busy high street
  - Player's job is to prioritise the multiple casualties for treatment
  - Trainees must follow set protocols to make decisions

http://www.trusim.com/?page=CaseStudy

Triage Trainer Video

RomaNova Case Study

- Serious game taking place in a replica of the antique city of Rome
- Aim is to teach history to young audiences
  - By means of an original engaging experience where the player is immersed in a crowd of virtual Romans

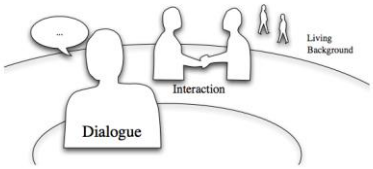
Doulamis, A., Liarokapis, F., Petridis, P., Miaoulis, G. Serious Games for Cultural Applications, Intelligent Computer Graphics 2011, Studies in Computational Intelligence, Plemenos, D., Miaoulis, G. (Eds.), Springer-Verlag, Volume 374/2012, 97-115, 2011. (ISBN: 978-3-642-15689-2)

Learning in Roma Nova

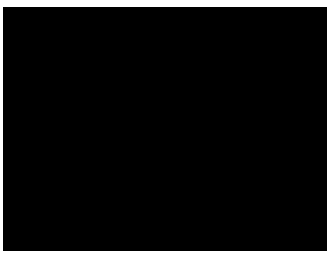
- Levels of detail and levels of simulation for:
  - Crowd modelling
  - Animation techniques for cultu heritage
  - Pedagogical embedded conversational agents
- Seeking to advance information transfer through immersive 'living background'

Level of Interaction Framework

- The LoI is a framework designed to model the interactions between the player and virtual characters, in a serious games perspective



Roma Nova Video



Online Virtual Environments

Virtual Environments (VEs)

- VEs are synthetic representations of reality
  - Focused on the experience that the users of these worlds have
  - Can be used by distributed groups of large numbers of players, and are immersive and interactive
- Many types exist
  - Focus is on Online Virtual Environments
    - Sometimes called 'Collaborative Virtual Environments'

Virtual Environments Experience

- Sensory Feedback – information about the virtual world is presented to the participant's senses
  - Visual (most common)
  - Audio
  - Touch
  - Smell
- Interactivity – the virtual world responds to the user's actions
  - Computer makes this possible
  - Real-time

Walking Experiment at UNC – Chapel Hill

Online VEs

- New ways of exploring web-based applications
  - Evolution of telecommunication technologies, web-services and software engineering
- Great range of different online virtual environments
  - More than 100 different ones

Collaborative Virtual Environments

- "Collaborative Virtual Environments (CVEs) are online digital places and spaces where we can be in touch, play together and work together, even when we are, geographically speaking, worlds apart…
- In CVEs we can share the experience of worlds beyond the physical" [Churchill/Snowdon/Munro 2001]

Key Components

- Graphic engines
- Displays
  - Monitors, HMDs, etc
- Interaction devices
  - Keyboard, mouse, trackers, etc
- Processing Systems
- Data Network

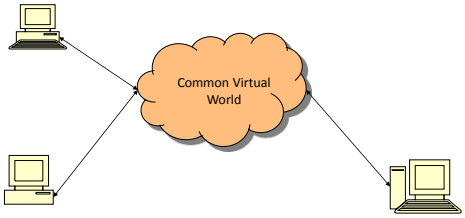
Types of VEs

- High realism online virtual gaming platforms
  - Custom, more experimental prototypes
  - Online game engines
- Alternative online virtual environments
  - Second Life, Active Worlds, OLIVE platform, etc

Typical Issues

- Some common research issues include:
  - What is the best virtual environment
  - What is the level of realism and interaction required
  - How best to design activities and experiences for learners

Basic Architecture

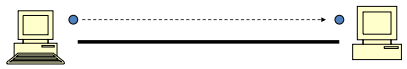


Current Challenges

- Network Bandwidth/Latency
- Heterogeneity
- Distributed Interaction (real-time)
- Resource Management - Scalability

Networking Concepts

- Latency
  - Amount of time to transfer a bit of data from one point to another
  - Latency has a direct impact on interaction inside the virtual world
  - The designer cannot really reduce latency
    - It is possible to hide it or reduce its impact



Networking Concepts .

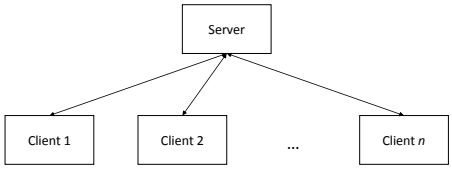
- Latency - causes:
  - Physical limitations: speed of electromagnetic waves in the transmission material
    - Approximately 8.25 msec per time zone
  - Delays introduced by the endpoint computers
  - Delays introduced by the network itself
    - Routers

Networking Concepts ..

TCP	Small number of users Limited data requirements Typically client-server configuration
UDP	Higher data requirements Used both in client-server and peer-to-peer configurations.
IP Broadcasting	Small peer-to-peer Net VEs with high data requirements and time sensitive delivery.
IP Multicasting	Large peer-to-peer NetVEs, be careful with routers.

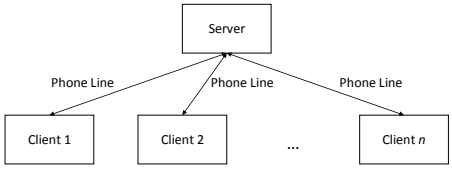
Architectures

- Client-Server Systems
  - Logical architecture



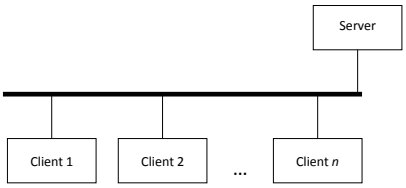
Architectures .

- Client-Server Systems
  - Physical architecture with phone lines



Architectures ..

- Client-Server Systems
  - Physical architecture on a LAN

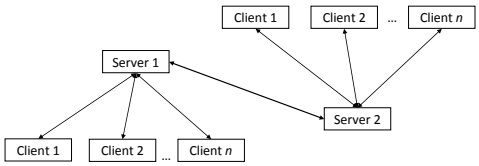


Architectures …

- Client-Server Systems
  - The Server can become a bottleneck.
  - What are the advantages? The server can decide::
    - Which clients should receive a message.
    - What protocol to use with different clients.
    - Sub-sample messages to slow users.
    - Keep statistics

Architectures ….

- Multiple-Server Architectures

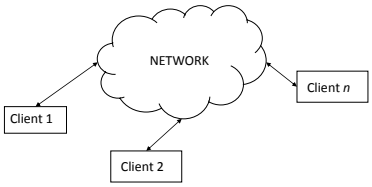


Architectures …..

- Multiple-Server Architectures
  - Several servers have the following advantages:
    - System scales better
    - Communication between clients attached to different servers takes longer
    - Key issue: how to assign clients to servers?

Architectures …..

- Peer-to-peer



Architectures ……

- Peer-to-peer
  - "Network" will be:
    - Broadcast
    - One or multiple multicast groups
  - In the case of multicast groups:
    - Area of Interest Management: assign different users to different multicast groups, based on some criteria

Technology Comparison

Technology	Speed (Kbps)	Min # players	Max # players
Modem	56	1	6
DSL	1500	39	163
T-1	1500	39	163
10BT	10,000	263	1085
100BT	100,000	2630	10851

Second Life – An example

- A typical illustration of online virtual environments is Second Life
  - 13 million registered accounts worldwide
- An open source approach exists
  - OpenSim

Second Life Video

https://www.youtube.com/watch?v=XOikYBbM9Yy&t

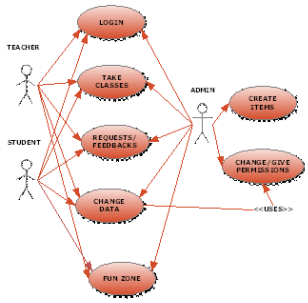
Case Studies

OpenSim Case Study

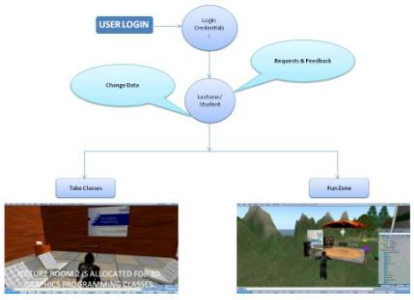
- Online Virtual Learning Environment
  - OpenSim
    - Open source
    - Creates dynamic online VEs
    - Allows customisation
    - Supports different database systems
- Aim:
  - Teach computer graphics University UG students

Jaligama. V, Liarokapis, F. An Online Virtual Learning Environment for Higher Education, Proc. of the 3rd International Conference in Games and Virtual Worlds for Serious Applications (VS-Games'11), IEEE Computer Society, Athens, Greece, 4-6 May, 207-214, 2011. (ISBN: 978-0-7695-4419-9)

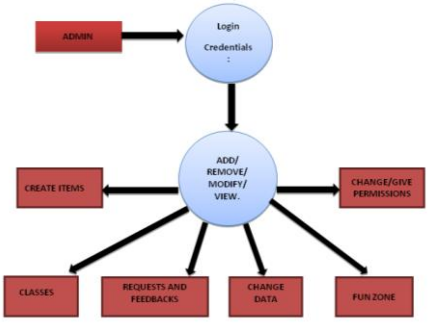
Virtual Learning Environment



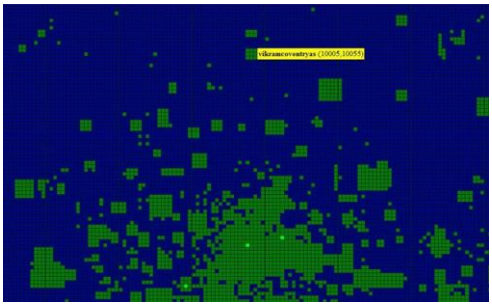
User-System Interaction



Administrator Privileges



Online VE Location



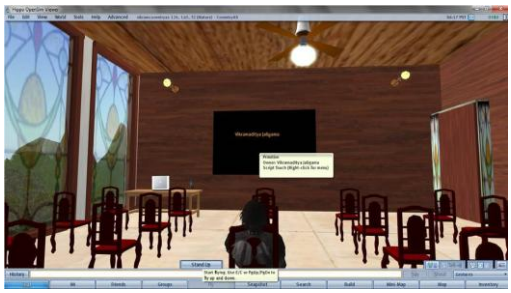
Modelling

Virtual Fun Zone

Online Teaching

- A 2nd year computer science undergraduate module has been ported into our online virtual learning environment
  - Called '3D Graphics Programming' and introduces 3D computer games graphic programming fundamentals to the students
- The theoretical part covers issues such as textures, global illumination and the simulation of physical phenomena

Online Virtual Classroom



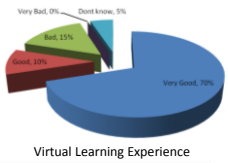
User Evaluation

- Two-stage evaluation with 20 participants was performed and qualitative and quantitative feedback was recorded
  - Participants ranged from students to business professionals
  - Evaluation lasted for approximately 1 hour per participant
- All end-users had some experience with computer games, console games or online virtual environments

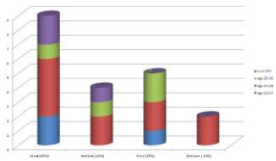
Qualitative Evaluation

- On the positive side, most participants noted that the platform is quite enjoyable and has a lot of potential for remote learning
- On the negative side, some participants did not like the idea of spending some time to familiarise with the platform

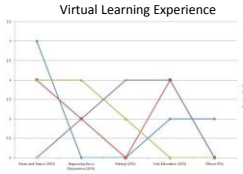
Feedback



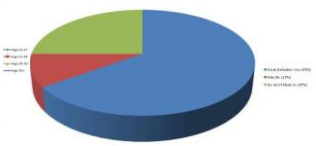
Virtual Learning Experience



Audio-Visual Effectiveness



Other Virtual Activities



Distance Learning Experience

Video 1

Video 2

Video 3

Videos

- http://www.youtube.com/watch?v=rZ5vzsNugVQ&feature=mfu_in_order&playnext=1&videos=_6TNubnT0To
- http://www.youtube.com/watch?v=HI7nrORinrg&feature=mfu_in_order&list=UL
- http://www.youtube.com/watch?v=NGf9BTGsAB8
- http://www.youtube.com/watch?v=a5itQRi7Sog&feature=mfu_in_order&list=UL

VS-Games Conferences

- VS-Games 2009, Coventry, UK
  - http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=5116537
- VS-Games 2010, Braga, Portugal
  - http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=5458389
- VS-Games 2011, Athens, Greece
  - http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?reload=true&punumber=5962074

IEEE VS-Games 2017

- Dates:
  - Submission: 30th April 2017
  - Conference: 6-8 September 2017
- Location:
  - Athens, Greece
- Website:
  - http://vsgames.org/2017/

Conclusions

- Serious games are becoming more and more popular
  - Expected to get 'serious' profits in the games industry
- Computer graphics technology is the same
  - For games and serious games
- More research is required in many areas
  - HCI, personalisation and pedagogy

Bibliography

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- Michael, D. & Chen, S. (2006) Serious Games: Games that Educate, Train and Inform. Boston, MA: Course Technology PTR
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Questions