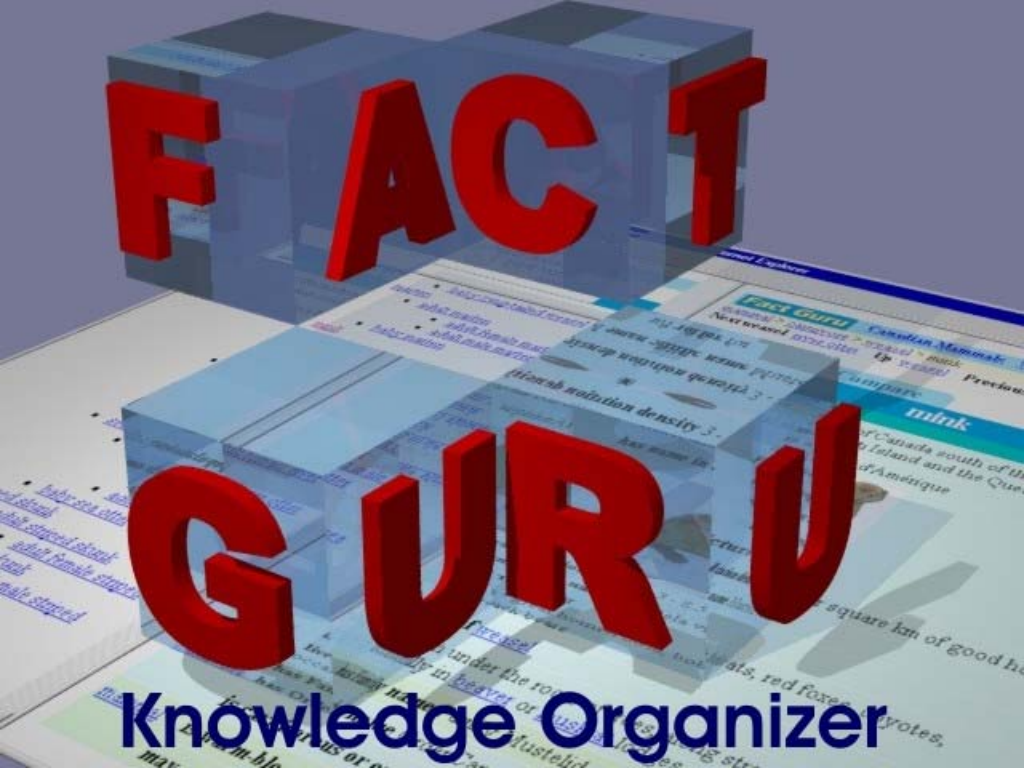
F AC T
G UR U
Knowledge Organizer

software: FactGuru Game
software category: Serious Games
summary: Combining AI with VR to disrupt education
document type: Design Document
author: John Talbot
date: 2013-09-28,
amended: 2015-02-19, 2015-08-27
URL: http://factguru.com

primary purpose:

Leveraging the true power of artificial intelligence (AI) in virtual reality (VR) educational games.
AI is used by the Ontologist to develop both the educational content and the virtual environment.
The resulting Ontology is then used by the game programmer to vastly simplify game design and development.

secondary purpose:
1. To familiarize the user with focus fusion technology and the promise it holds for solving all our energy problems.
2. To teach the scientific method via an example in astrophysics : The thesis that belief is stronger than reason
is exemplified using the Laser Star Theory, a Nobel Prize-winning model of quasars.

stealth learning:
educational materials presented non-traditionally (e.g. gradually) so that the user does not immediately recognized they are being taught. The user gradually uncovers portions of the Ontology as they progress in the game via the game 'mechanics'. Ultimately the user learns to appreciate the benefits of AI and virtual reality in their educational development.

virtual reality:
computer generated 3D environment, artifacts and computer mediated interactions with user

artificial intelligence:
Knowledge represented as an Ontology.
Ontology semantically linked to virtual reality such that first order logic mediates both user and programmer interactions with environment and artifacts.
Knowledge base augmented with pedagogical learning threads (pedagogical markup knowledge about knowledge, a kind of metadata)
(i.e. users can create their own threads depending on their interests)
Users and programmers have identical capabilities except for publishing and internet sharing
Linguistic minimalism.

Implemetation
concept, relationship, fact

graphical user interface:
Graphs, Tree Views and Tables in 3D VR

Implementation of primary purpose:

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knowledge base structure, knowledge encoding formats
SysML, UML, XMI parser-interpreter controls the simulation of scientific instrument artifacts

FactGuru text import
conceptual graphs
Python, C++, Java
Unreal Engine 4 Blueprints
Open Source Robotics Framework

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design:
SysML, UML

design tool:
Visual Paradigm for UML Professional v12.2
Blender v2.76
Autodesk Maya 2016 Extension 1 Service Pack 2 LT
Epic Games Unreal Engine 4.9.2
Microsoft Visual Studio 2013 Community Edition Service Pack 5
Allegorithmic Substance Designer 5, Substance Painter and Bitmap2Materials
Open Graph Drawing Framework v.2015.05 (Baobab) http://www.ogdf.net/doku.php
Adobe Creative Suite Ultimate CC
Native Intruments Komplete Ultimate
Cubase 8

design sharing:
GitHub

implementation:
1. C++ with full round trip UML and marked up with Unreal macros
2. Ontology

design details:
Systems engineering is used to model scenarios, environments, artifacts and processes.
User interactions with environment, artifacts and processes is the basis for the game.

design goal:
- PROBLEM: Create a separation of concerns between the low level C++ and the knowledge base.
- SOLUTION: Use the Ontology to simultaneously describe both the knowledge and the game implementation details.
1. Users can browse the knowledge independently of game implementation details
2. Programmers enter knowledge into the Ontology instead of C++ programming
(a) add to the world by creating geometrical content in UDK, Blender or Maya
(b) associate geometrical content with physics knowledge in the Ontology
(c) associate geometrical content with game implementation details in the Ontology

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Ontology-based educational game:

Physical model maps directly to the conceptual model. Various physical phenomena share a common subset of fundamental physical behaviors this leads to the following problem:

PROBLEM
(1) Fact: In standard educational materials each document must duplicate this common set.
Consequence: Students waste time sifting though this re-introduced material for new knowledge.

(2) Fact: Differing fields of study have different terminology for common topics.
Consequence: Students are confused by the myriad of synonyms as they study different fields.

(3) Fact: Documents refer to other documents.
Consequence: Students waste time searching and aquiring these linked documents.
Students waste money aquiring documents that are paywalled or only available at bookstores.

(4) Fact: Relationships between concepts are not obvious, they are scattered within the documents.
Consequence: Student must digest all the materials before these relationships emerge.

SOLUTION:
(1) The Ontology facilitates the sharing of this commonality by having a central location for the storage of this knowledge. Subject, topic or fact in the Ontology can have an associated personalized boolean 'visited' value (similar to alternate link color of visited web pages). In addition, each subject, topic or fact can store the user's personalized proficiency level indicating their level of mastery in the associated subject matter.

(2) Unified terminology; Preferred terms are chosen and synonyms are avoided.

(3) The need for external reference is dramatically reduced since most of the required knowlegde is contained in the Ontology therefore most reference links are internal.

(4) Graphs make the relationships between concepts immediately obvious.

Serious Games:

Leverage the compelling, fascinating nature of games and positive psychology :
irresistible alluring appealing captivating charming delightful enchanting engaging engrossing glamorous gripping intriguing riveting bewitching enticing ravishing seducing attractive delectable
reference: Reality is Broken and SuperBetter (Jane McGonigal) ISBN:

Montessori Education:

"Education for a New World" Conference given by Maria Montessori in New Delhi, India (1943)
Montessori-Pierson Publishing Company
Kalakshetra Publicationss
http://en.wikipedia.org/wiki/Montessori_education

Isaas Asimov baseball analogy : Steps for seeking higher learning
http://en.wikipedia.org/wiki/Isaac_Asimov

Karen Effect : a maximum of interactivity, Fisher-Price busy box (robotics)

Foundations of Physics:
Empirical methodology is a part of the scientific method
The Big Bang Never Happened (Eric Lerner 1992) ISBN: 067974049X
http://www.amazon.com/Big-Bang-Never-Happened-Refutation/dp/067974049X
http://en.wikipedia.org/wiki/Methodology
http://en.wikipedia.org/wiki/Empiricism
http://en.wikipedia.org/wiki/Scientific_method

====== Conceptual Model ==========

The physical models such as environment, artifact or process are mapped to conceptual models contained in a knowledge base (Ontology)

Knowledge base structure :

- Each concept or topic has :

- Definition
- Facts
- Relationships with other concepts or topics

- Each concept, topic or fact has :
  - Topic(s) under which they are classified
  - Level-of-detail
    This value represents succesively more detailed exposition, the inverted pyramid technique used by reporters
    Purpose:
      1 - A thresold to reduce clutter when browsing
      2 - Optionality value so users can select an upper bound on the level-of-detail
      3 - The threshold can be set automatically based on user age, educational backgroud or learning progression rate (as they 'level-up')

- Presentation and navigation methods :
  Each concept, topic or fact can have multiple level-of-detail values associated with each presentation method below :

  - a select set of important facts and inherited facts
  - a select set of super-concepts and sub-concepts as links
  - a select set of parts and part-of facts
  - top level concepts first and progressively deeper in kinds and parts
  - Instances first and and progressively more general super concepts
  - thread or tutorial : pedagogical sequence of topics, concepts or facts
  - ?? limit exposition by automatically assigning a lower level-of-detail value to each succesive link traversed (indirection threshold)
  - topic hierarchy
  - parts hierarchy
  - the sun graph display mode

Implementation of secondary purposes:

There is a beneficial synergy between phenomena in nature and in experiment:
(a) NATURE: observation of nature
    - like an uncontrolled experiment with a set of parameters. Some parameters are known some unkown.
(b) EXPERIMENT: experiments in laboratories
    - many parameters can be chosen for each experimental run
    - can model or reproduce a naturally occuring phenomena

The phenomena to be studied are analyzed into a hierachy of fundamental physical behaviors each associated with experimental apparatus. The Ontology Level-of-detail value for each experiment contributes to the smooth and gradual progression of learning.

1. Focus fusion

(a) NATURE: Plasma filaments in space (aurora, solar filaments and flares)
(b) EXPERIMENT: Plasma focus

1. observation
  1. Aurora
  2. Solar prominence
  3. Solar flare

2. Maxwell's equations
   1. current
   2. charge
   3. Faraday's law of induction
   4. electric fields
   5. magnetic fields
3. collective plasma phenomena
   1. exploding double layers
   2. force-free filaments
   3. 3D PIC simulation
4. fusion
   1. aneutronic
   2. neutron producing
   3. tokamac
   4. inertial confinement
   5. focus fusion

2. Belief is stronger than reason : Laser star astrophysics

(a) NATURE: Laser Stars (quasars, cpn, Wolf-Rayet stars)
(b) EXPERIMENT: Industrial UV and X-Ray plasma lasers

1. observation, experimental results and simulations
   1. quasars, cpn, Wolf-Rayet star spectra
   2. Collisional-Radiative simulation
2. laser action
   1. stimulated emission
   2. spontaneous emission
   3. population inversion
   4. amplified spontaneous emmission
3. plasma
   1. static: ionization and excitation balance at a given temperature and density
   2. dynamic: adiabatic expansion cooling thermodynamics
   3. dynamic: contact cooled
   4. classification
      1. recombining
      2. collisionaly excited (Nova-laser generates x-ray laser)
      3. ionizing
      4. decaying
4. applications
   1. industrial uv and x-ray plasma lasers
   2. diagnostics for fusion plasma

========== Physical Model ==========

Levels or phases of exploration are modeled using the empirical methodoly

1. Physical World
   1. Environment | has part | artifact | -has cardinality: zero or more
      | has part | process | -has cardinality: zero or more
      1. natural
         1. celestial object
         2. space
      2. artificial
         1. facility
         2. floor
         3. elevator or lift

4. corridor
5. room

2. Artifact
1. experimental device
1. power supply
2. electronics
3. sensor
4. active volume location (where physical phenomena take place)
2. poster
3. tool, equipment
1. tricorder
2. tablet
3.
3. Process
1. Natural process
2. Experiment

2. Experiment operation

3. Experiment results

4. Formulate a model which reproduces the results

========== Virtual Reality : Action Model ==========

The user or robot can interact (or perform actions) with (1) environment (2) artifact or (3) process

1. Environment Action
change location

location
artificial location
spacecraft
satellite
transporter
facilitie
corridor
room
natural location
celestial body
galaxy
star
planet
asteroid
space
orbit
hyperbolic
parabolic
elliptical
three body
surface
continent
island
body of water
sea
ocean

lake
river
crater
marea

2. Artifact Action
locate
create-destroy
move
operate
assemble composite artifact from two or more artifacts
disassemble composite artifact
connect artifact to artifact (connected artifacts don't combine to create a composite artifact)
disconnect artifact from artifact
destroy
recycle

3. Process Action
high level process
run experiment
observe natural phenomena
mid-level process (more than two particle)
thermodynamics
low level process
creation-anihilation
collision
transition
propagation
molecule formation-dissociation

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environment: (locations which user can be on or inside)
| has part | environment (for composition) | -has cardinality: zero or more

celestial body
planet
Earth
Mars
satellite
Moon
Phobos
Deimos
asteroid
Vesta

geological formation
continent
mountain
volcano
crater
island
cave
sub-oceanic

facility
university

  laboratory
  institution
  corporation
  outpost
  orbital station
room
  laboratory room
  classroom
  meeting room
  supply room
  operations room
  decompression room
  virtual set : (a kind of virtual reality within the game's virtual reality)

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artifact:

artifact
  composite artifact : a kind of artifact which is composed of other artifacts (can be assembled or disasembled)
    experiment
    energy generation
    matter generation
      mining
      extraction
        distilation
        filtering
  container
    test tube
  connector : a kind of artifact which connects zero or more artifacts together
    tube
    cable

utility (a kind of resource flow composed of energy or matter. Can be represented as a SysML port)
  energy
    free-space
    waveguided
    electricity
      alernating
      direct current
      electron beam
      electron flow over conductors
    photon
      microwave
      laser
  matter
    cryogenic
    liquid
      water
    gas
      hydrogen
      helium
    solid
    plasma

vehicle
    dynamic

transporter
static
two body orbit
three body orbit
Lagrange point

---

process:

interaction process | is a kind of | process
| has definition | a kind of process which involves user interaction or user action in the game
physical process | is a kind of | process
| has definition | a kind of process which involves one or more laws of physics
experiment
phenomenon | has definition | http://en.wikipedia.org/wiki/Phenomenon
| has definition | what is experienced is the basis of reality
| has plural | phenomena
collision
thermodynamic
chemistry

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scenario | is a kind of |
| has definition | container for environment with zero or more artifact and zero or more process
| has part | environment
| has part | artifact | -has cardinality: zero or more
| has part | process | -has cardinality: zero or more
| has part | person | -has cardinality: zero or more
| has location |
| has time |
| has topic |
| has educational thread | ordered collection of facts about certain concepts

2D scenario | is a kind of | scenario
| has definition | Software displaying and discussing experimental results, theories or facts mostly two dimensions with some 3D graphs

3D scenario | is a kind of | scenario
| has definition | A kind of scenario which is represented within a virtual reality
| has representation | virtual reality
| has implementation | virtual reality implementation
| has part | 2D scenario | -has cardinality: zero or more

science fiction | is a kind of | 3D scenario
| has part (environment) | facility, laboratory
| has part (artifact) | vehicles and technical instrumentation
| has part (person) | astronaut, engineer, worker, scientist, politician
| has location | space, moon, planet
| has time | future

historical | is a kind of | 3D scenario
| has part (artifact) | instrument of discovery
| has part (person) | scientist or author of discovery
| has location | historically accurate location of discovery
| time | time of discovery

ordinary daily life | is a kind of | 3D scenario
| has part (artifact) | educational tools (blackboard, whiteboard, experimental

demonstration)
| has part (person) | teacher
| has location | variable
| has time | present

virtual reality implementation options
Unreal
Crysis
Unity

References:
http://factguru.com
http://en.wikipedia.org/wiki/Learner-generated_context