Generating materials for augmented reality applications using natural language

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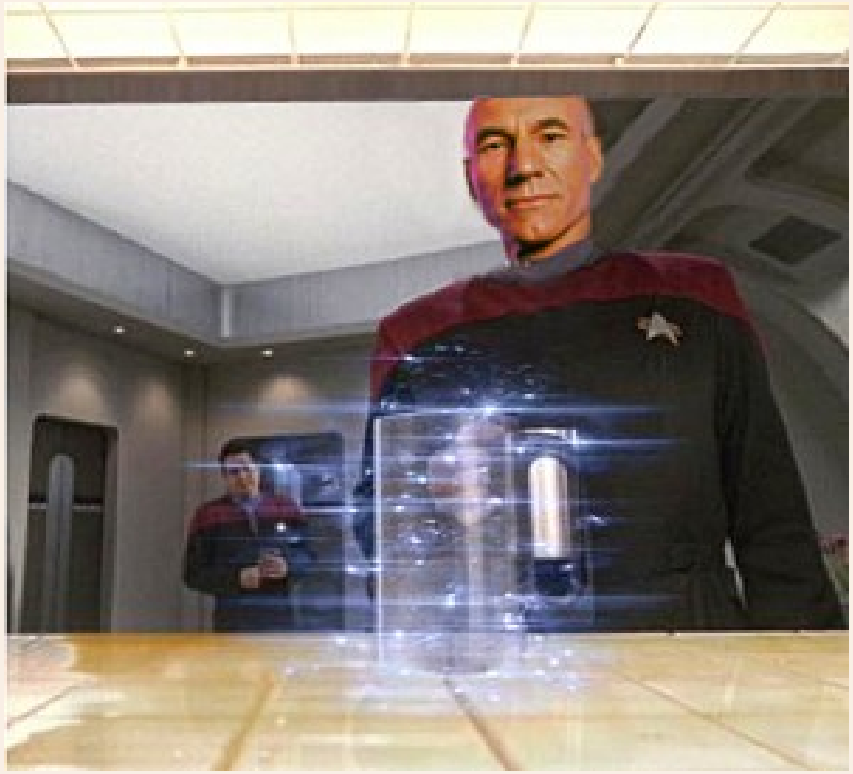
Human-Machine-Interfaces

- Famous Captain Picard:
- „Tea, Earl Grey, hot“
- 'Ultimate' HMI
- Computer creates product based on short description given in Natural Language
- includes personal taste of user (you can do a lot wrong with Earl Grey!)



Human-Machine-Interfaces

Goal

- find a simple interface to solve (computational) complex problems
- in my case: for materials used in 3D computer graphics
- $\rightarrow$ **parametrize the BRDF using natural language**

Material creation in Computer Graphics

Micro-Facet BRDF

$$f(\vec{x}) = \frac{F(\eta_1, \eta_2)G(m)D(m)}{4(\vec{N} \cdot \vec{L})(\vec{N} \cdot \vec{H})} \tag{1}$$

$$D(m) = \frac{m^2}{\pi((\vec{N} \cdot \vec{V})^2(m^2 - 1) + 1)^2} \tag{2}$$

$$G(m) = \frac{2}{1 + \sqrt{m^2 + (1 - m^2)}} \tag{3}$$

$$F(\eta_1, \eta_2) = (\frac{\eta_1 - \eta_2}{\eta_1 + \eta 2})^2 + (1 - (\frac{\eta_1 - \eta_2}{\eta_1 + \eta 2})^2)(1 - \vec{H} \cdot \vec{V})^5 \tag{4}$$

Material creation in Computer Graphics

Micro-Facet BRDF

- complex Formula, hard to handle by non-CG people
- extremely unintuitive
- in end-user scenarios, materials are usually selected out of predefined datasets

Natural Language for Materials

Examples

- „blue anodised Aluminium“
- „brown varnished Wood“

Natural Language

- gives a sufficient description of the Material
- is the preferred way humans would describe materials to each other

Finding the right words

basic vocabulary

- experience-based
- Adelson „On seeing stuff“
- extended using synonyms and antonyms
- classified in Adverbs, Adjectives, Nouns

User input

Input

- User 'enters' verbal description (Speech-to-text, keyboard,...)
- input has to follow simple grammatical rules adopted from NL

Grammar rules

Basic rule system

- Nouns (Aluminium, Wood, Brass,...)
- Adjective Noun (anodised Aluminium, varnished Wood, polished Brass)
- Adverbial-adjective Adjective Noun (blue anodised Aluminium, white varnished Wood)
- multiple 'Adverbial-adjective Adjective' terms, separated by comma, followed by Noun (lightly brushed, blue anodised Aluminium)

Processing

Steps

- POS-Tagging
- Finding the base form (anodised $\rightarrow$ anodise)
- Mapping
- Output

POS-Tagging and Baseform

Scheme

- Noun $\rightarrow$ denotes base material
- Adjective $\rightarrow$ modifies the materials appearance
- Adverbial-adjective $\rightarrow$ modifies adjective

POS-Tagging and Baseform

Example - „blue anodised Aluminium“

- Aluminium - silverish, highly specular material
- anodised - enhances the top oxide layer of the Aluminium, material becomes more diffuse
- blue - colour of the anodisation process, changes RGB-value

Mapping

Problem

- intent vs. interpretation
- e.g. which „blue“ does the user mean? light blue? navy blue?
- more or less unresolvable issue

Possible Solution

- after the first result, the user can apply further modifiers like
- more, less, stronger, darker, lighter,...
- „darker blue“, „more brushing“

Mapping

Database

- Database with baseform word entries
- several modifiers for each word
- each modifier can influence parts of the parametrisation

Mapping

Micoscopic structure

The microscopic structure (e.g. roughness) is represented by the parameters of the BRDF itself (e.g. m, η_1, η_2, k)

Parameters (isotrop)

- $m \rightarrow$ roughness coefficient
- η_1 and $\eta_2 \rightarrow$ index of refraction
- $k \rightarrow$ extinction coefficient

Parameters (anisotrop)

- $\alpha_x \rightarrow$ roughness $\vec{x}$
- $\alpha_y \rightarrow$ roughness $\vec{y}$
- $\rho \rightarrow$ magnitude of BRDF lobe

Mapping

Macroscopic structure

Macroscopic effects like abbrasive machinery (brushing) are applied using textures and normal maps. These are generated procedurally. The procedural generator will be parametrised by the natural language as well.
Example:

- brushed $\rightarrow$ generates normal map for brush strokes
- wood $\rightarrow$ generates wood texture

Output

Target system

The output is generated depending on the target system. All systems that support analytic BRDF (CT and Ward) as well as textures and normal maps are supported.

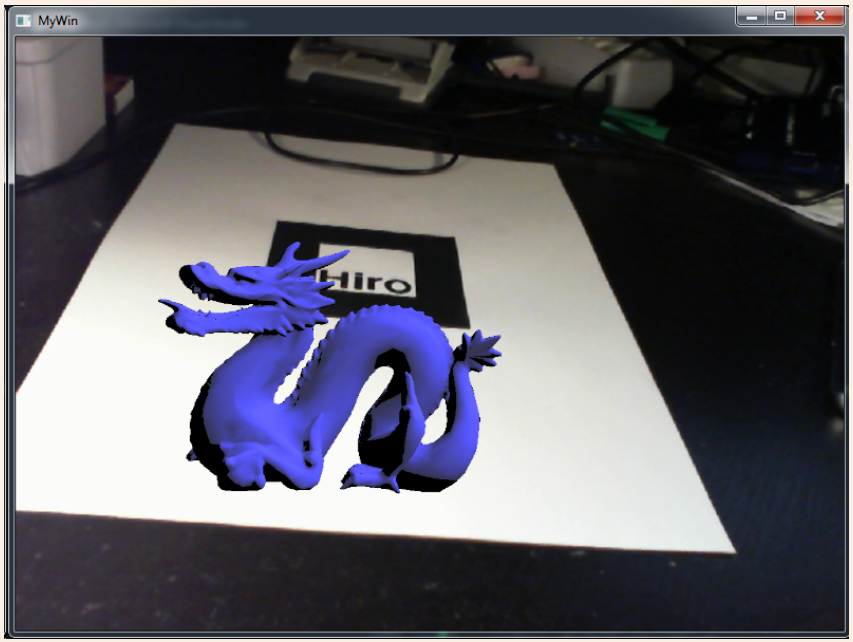
System Design

MATZ

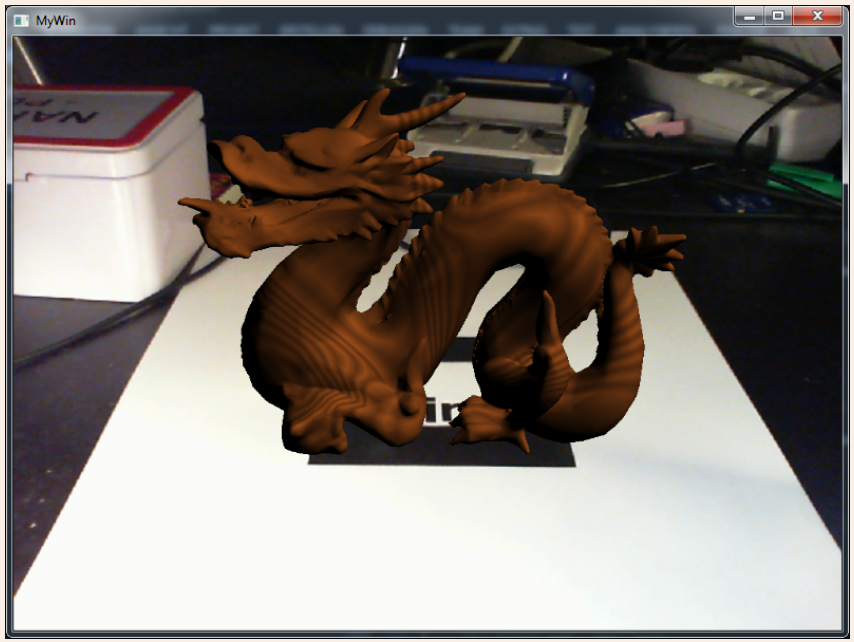
- Input Plugins - Speech-to-text, Webforms, plain-text-file
- Core Processor - POS-Tagging $\rightarrow$ Mapping $\rightarrow$ Output Parameter set (OPS)
- Output Plugins - Bundle OPS for Target Platform (ThreeJS, Unity, OpenGL+ARToolKit5)

Results

blue anodised Aluminium



dark wood



Outlook

Materials

- Big Data approach - find most suitable parameter set by comparing
- Output for Raytracers (PBRT, MentalRay,...)

Natural Language

- using Natural Language for Interiour Design (work-in-progress)