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Mastering real-world materials using bidirectional texture functions

ORREALIA™

Interactive photo-realistic 3D digital prototyping

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onesia - Presentation

- Onesia develops and markets **real time interactive photorealistic 3D rendering** for computer-aided design, scientific visualization, and industries that require virtual prototyping
- Orealia™ is the **first entry-level virtual prototyping solution** offering the power of high-end 3D rendering softwares

oralia - Adressed problems

- Product design is too slow
  - ✓ *reduce time to market*
- Costs of Physical prototypes are too high
  - ✓ *no longer required*
- The interaction between Production and Marketing departments is difficult
  - ✓ *user-friendly interface to share data*
- The quality of the output is not realistic
  - ✓ *enough to be used "out of the box"*

orealia - Workflow

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IMPORT OPTIMIZE	DESIGN MARKET	DEPLOY SHARE
		
Catia Pro/Engineer SolidWorks Rhino 3D Google SketchUp ...	Lighting Materials Variances Interactivity	Stand-alone App Web 2.0 Image/Video Virtual Reality

① → ② → ③

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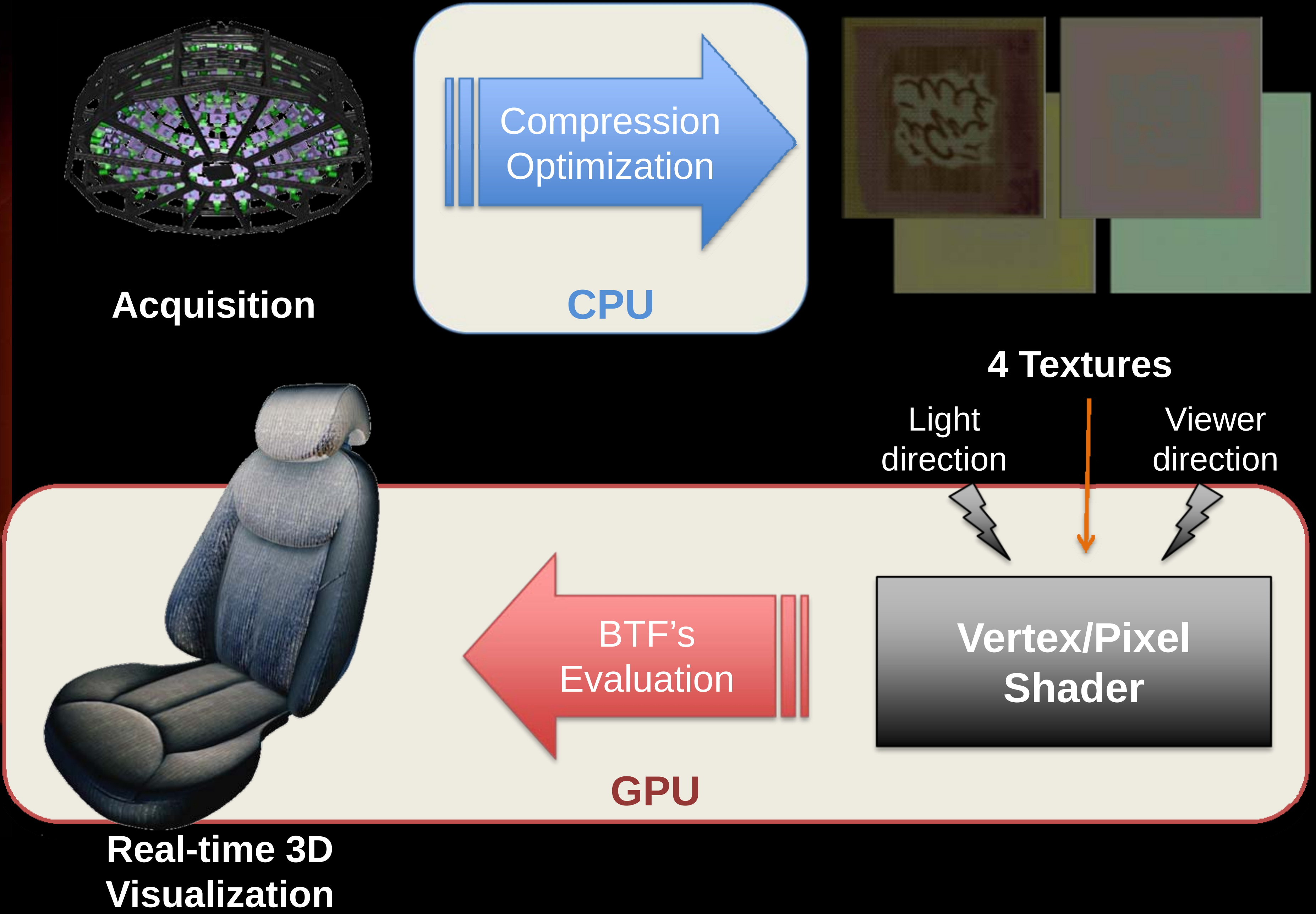
orealia - BTF (Bidirectional Texture Function)

- Goal : capture the appearance of real-world materials and apply it to virtual prototypes in real-time

- Single texture (photograph)
  - x simple but unrealistic : flat appearance
- Textures for different lighting/viewing configurations
  - ✓ realistic : reflection, anisotropy and self-shadowing

orealia - BTF overview



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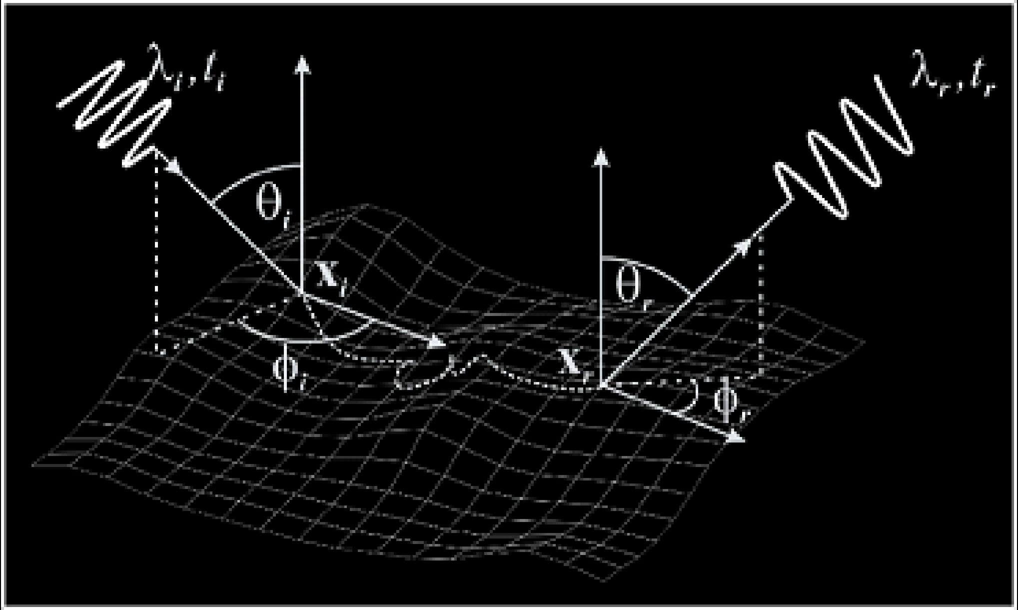
orealia - BTF definition

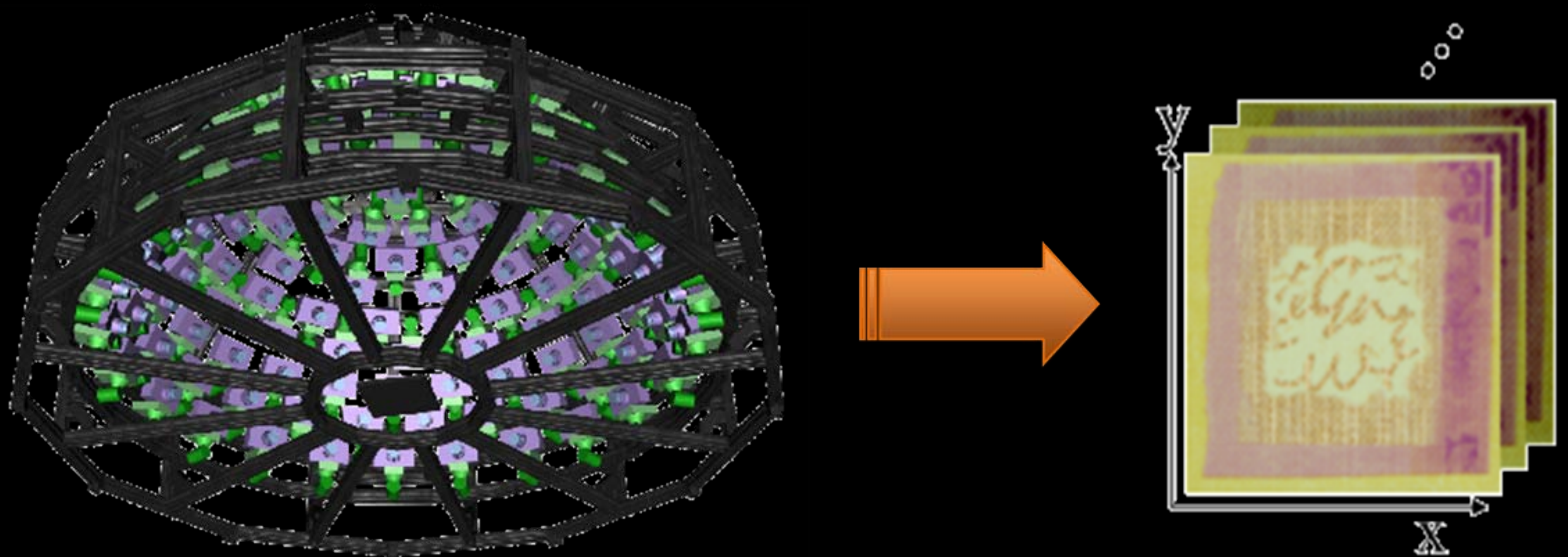
- Light-Matter interaction is quite complex !
  - ✓ function defining how light is reflected on a surface



- We need to simplify
  - ✓ $t_i = t_r$, $\lambda_i = \lambda_r$, $x_i = x_r \rightarrow$ BTF
  - ✓ if invariant with respect to x (plain color) → BRDF

orealia - Acquisition

- Measurement device example
  - ✓ 151 digital consumer cameras (Canon PowerShot A75)
  - ✓ 2/3 measurements per day
    - post-processing required for shiny materials like paint



- Generates a huge amount of data
  - ✓ 81x81 lighting/viewing directions – 256x256 = 1,3 GB

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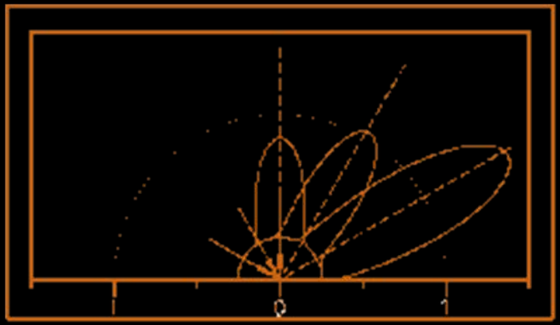
orealia - Modelling

- BTF viewed as a spatial-varying BRDF [McAlliste et al.]
- For each pixel we use the Lafortune's model

$$f_r(\omega_i \to \omega_r) = \rho_d + \sum_j \rho_{s,j} \left[\begin{bmatrix} \omega_{r,x} \\ \omega_{r,x} \\ \omega_{r,x} \end{bmatrix}^t \begin{bmatrix} C_{j,x} & & \\ & C_{j,y} & \\ & & C_{j,z} \end{bmatrix} \begin{bmatrix} \omega_{i,x} \\ \omega_{i,x} \\ \omega_{i,x} \end{bmatrix} \right]^{n_j}$$

✓ Generalise the Phong's model
✓ Non-linear
✓ Anisotropic
✓ Adapted to a wide range of materials



orealia - Compression

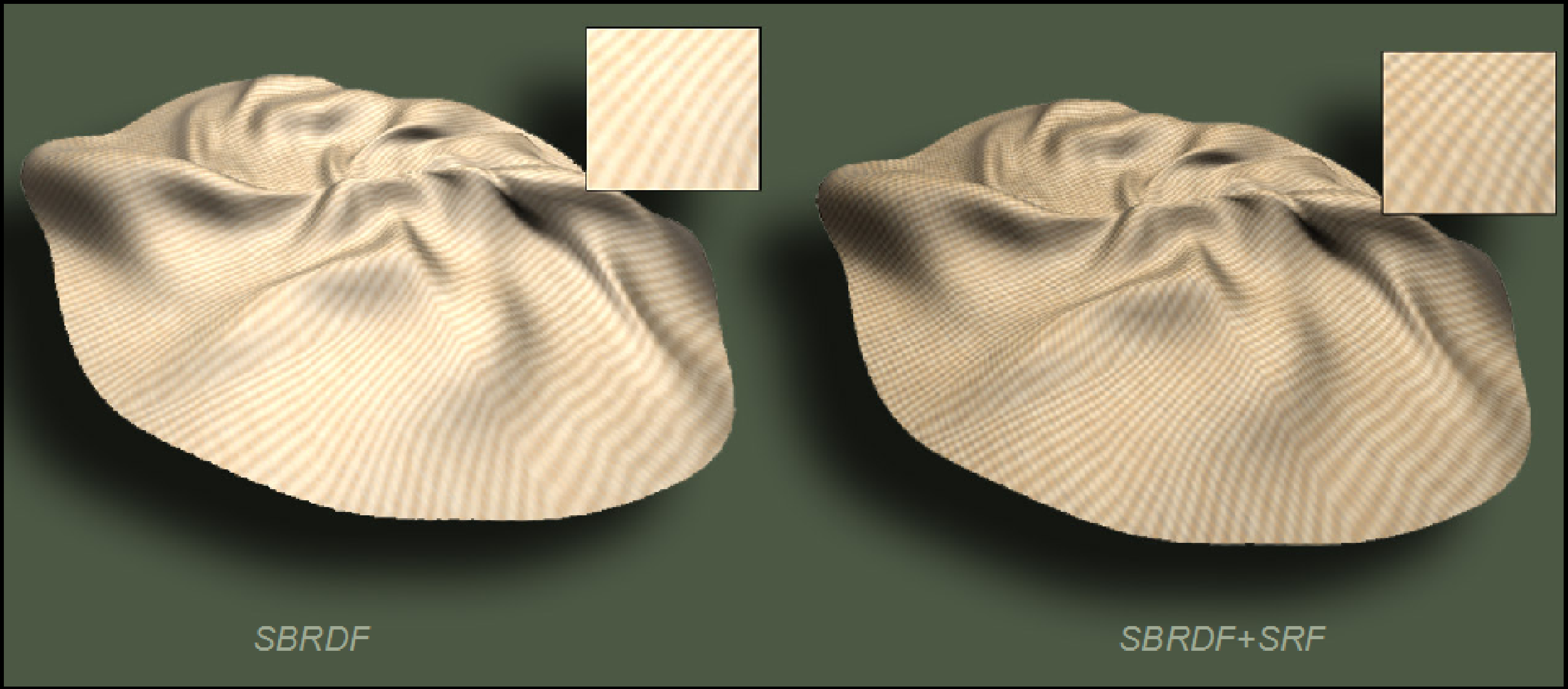
- Parameter estimation

$$BTF(x, \omega_i, \omega_r) \approx \rho_d + \sum_j \rho_{s,j} (\omega_r^t \cdot C_j \cdot \omega_i)^{n_j} + s(x) \cdot H$$

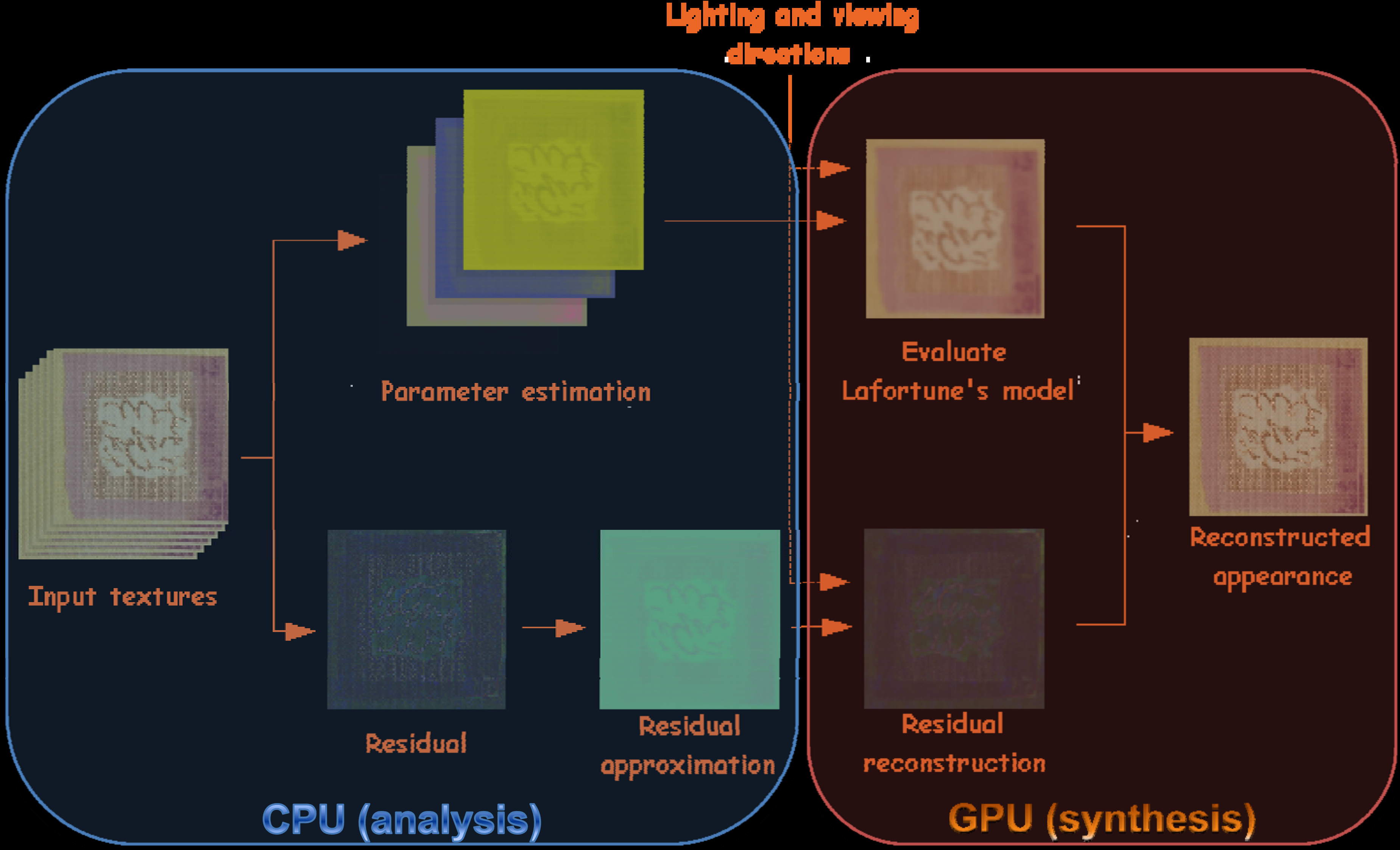
1. Diffuse component : ρ_d = minimum of all values
2. Albedo simplification : ρ_s is common to all lobes
3. Lobes : find best $C_{x,j}$, $C_{y,j}$, $C_{z,j}$, n_j ($j < 3$)
   - ✓ Levenberg-Marquardt non-linear optimisation
4. Residual s(x) to model the error
   - ✓ least square approximation of $BTF(x, \omega_i, \omega_r) - f_{r,x}(\omega_i, \omega_r)$

orealia - Reconstruction

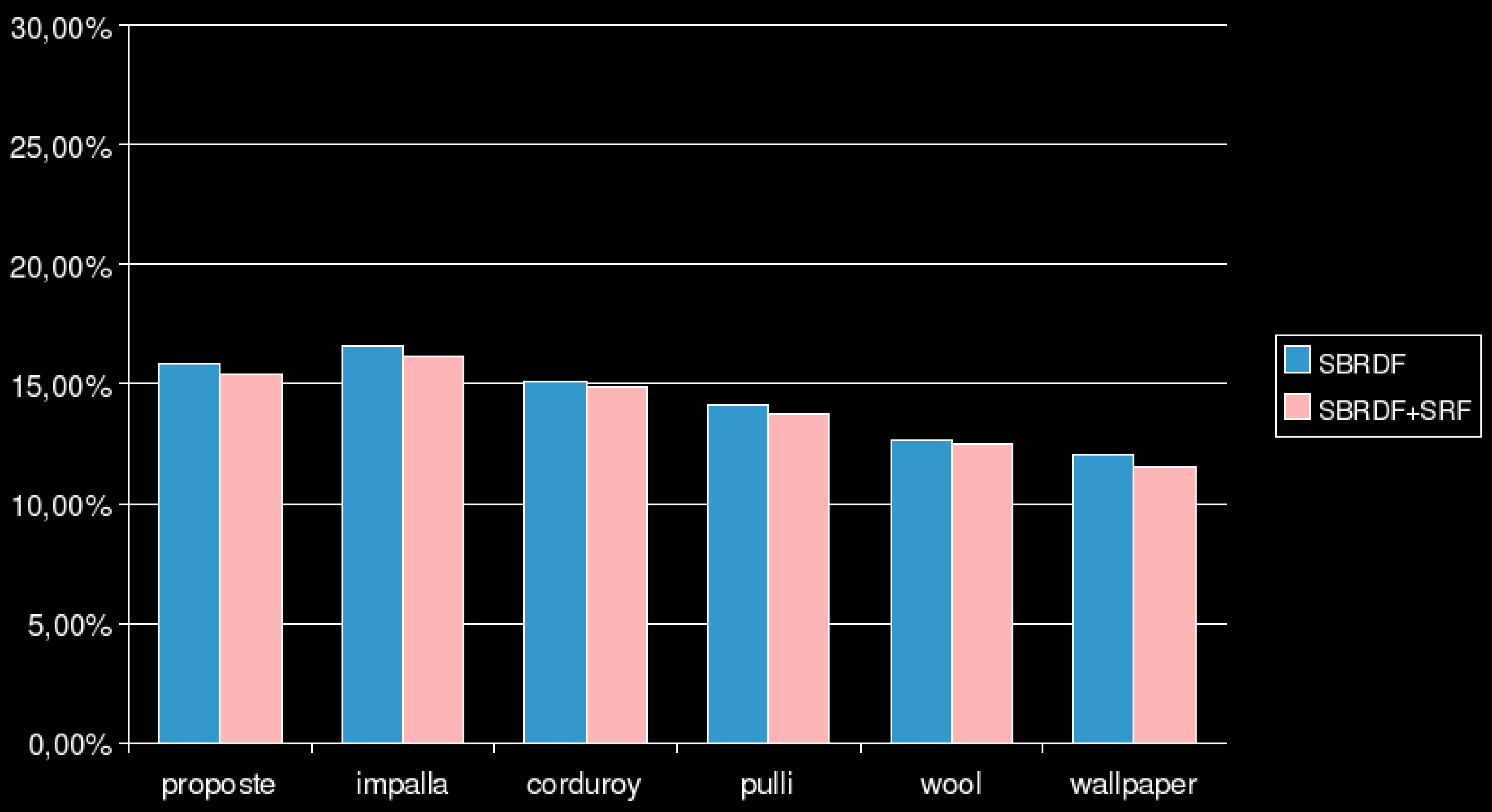
- Performed through a vertex/fragment shader
  1. Retrieve texture coordinates
  2. Filter parameters stored in textures accordingly
  3. Compute light/viewing configuration
  4. Evaluate Lafortune's model + residual accordingly
  5. Evaluate the rendering equation (sum up light contributions)



orealia - BTF pipeline summary



orealia - Results (error)



orealia - Results (speed)

orealia - Results (demo)

- This work is based on a technological transfer
  - ✓ partnership with IRIT/UPS/CNRS (Toulouse - France)
- This work used public data
  - ✓ provided by the Graphics Lab at Bonn University

THANKS FOR YOUR ATTENTION

You are welcome at

ONESIA booth B8