

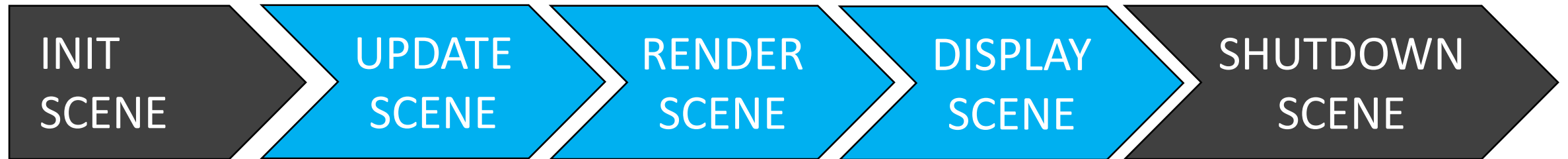
FRAMEBUFFEROBJECTS (FBOs)

Maximilian Querfeld - 28.11.2020



- Aufbau eines FBO
- Motivation
- Livedemo: FBO
- Anwendungsbeispiel: IBL
- Livedemo: IBL

RENDERING-PIPELINE

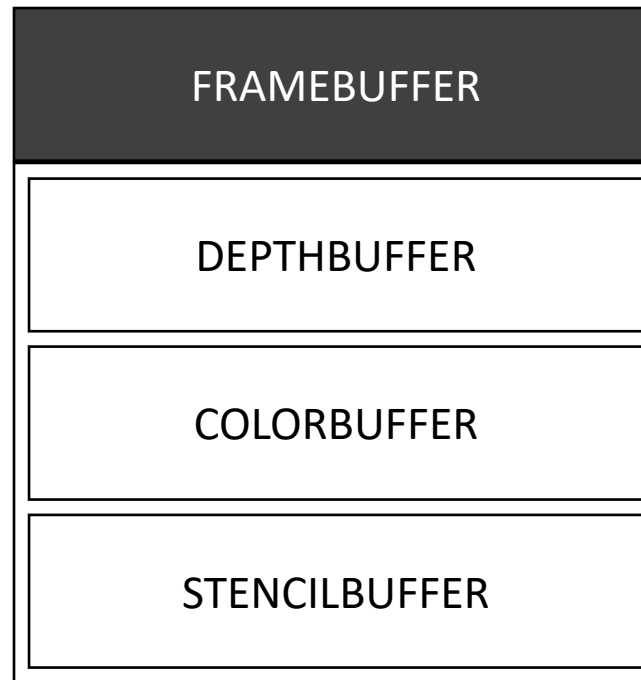


RENDERING-PIPELINE

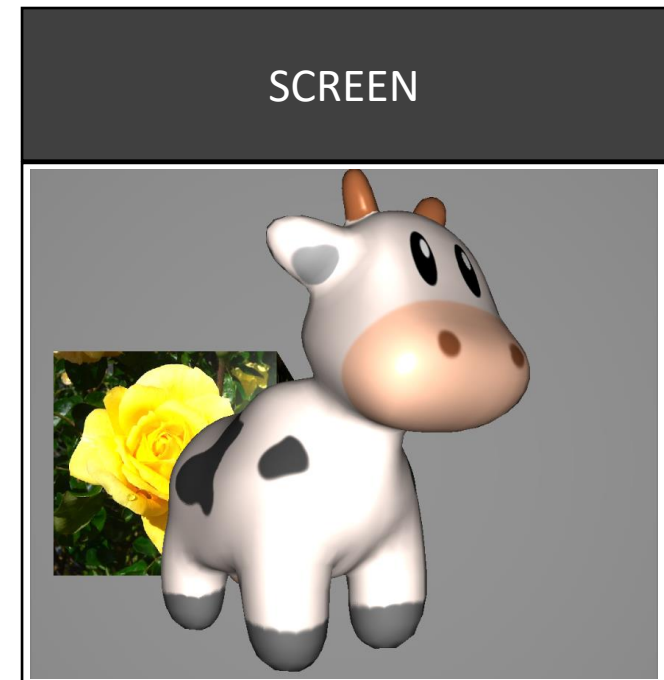
UPDATE
SCENE

$$T = \begin{bmatrix} & \dots & \\ \vdots & \ddots & \vdots \\ & \dots & \end{bmatrix}$$

RENDER
SCENE

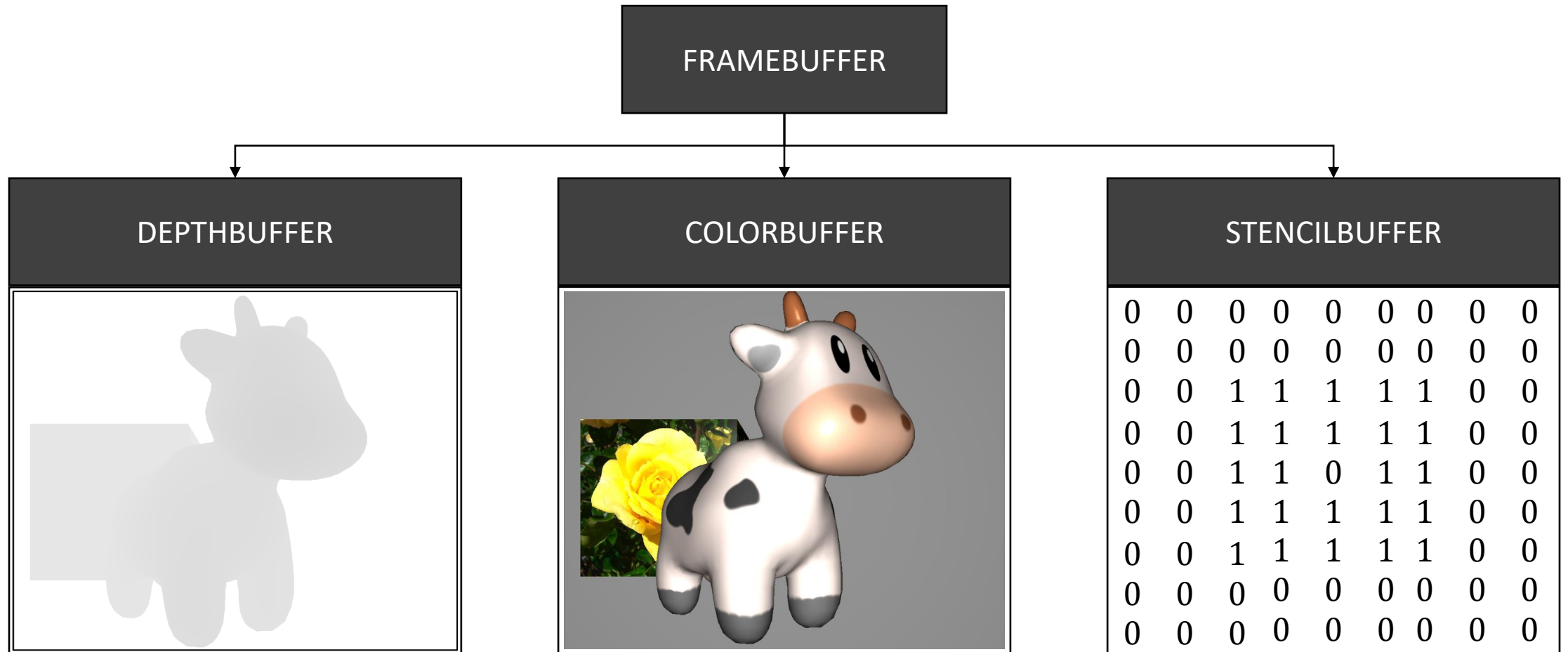


DISPLAY
SCENE

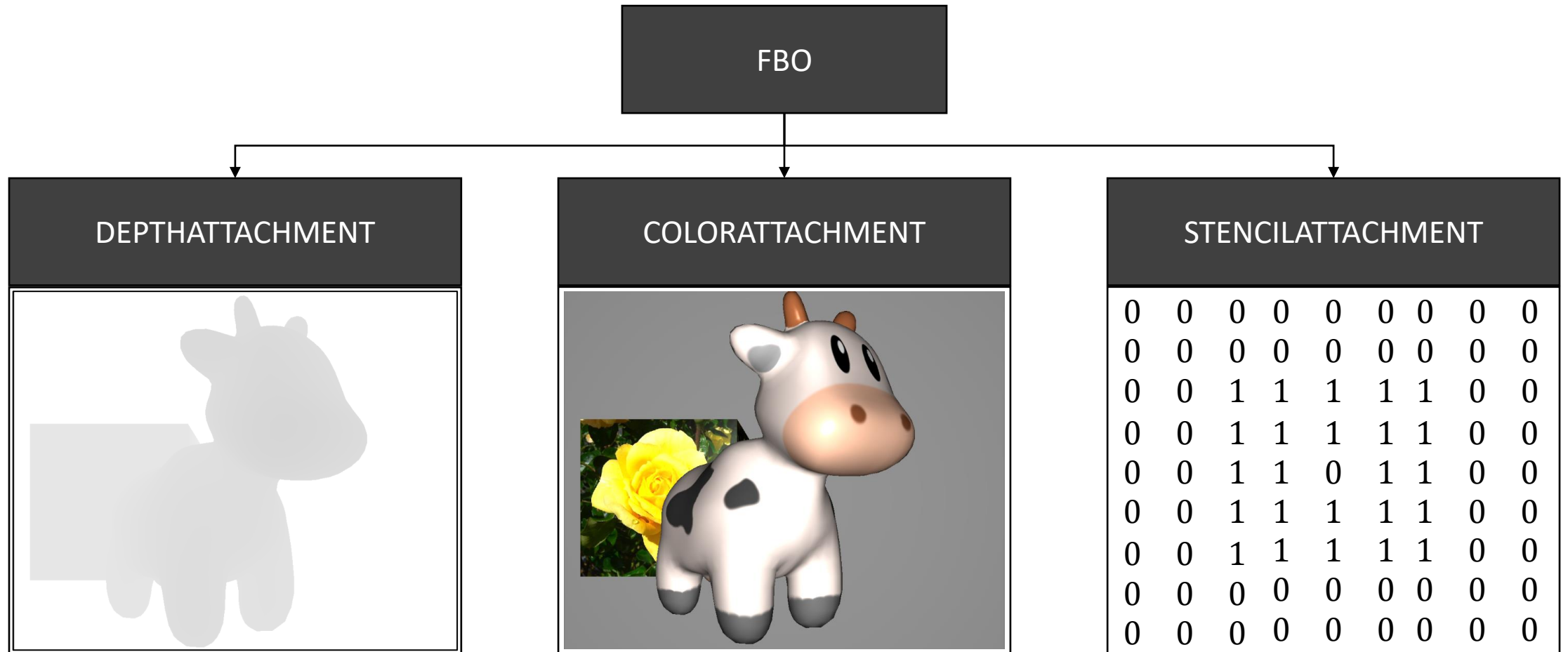


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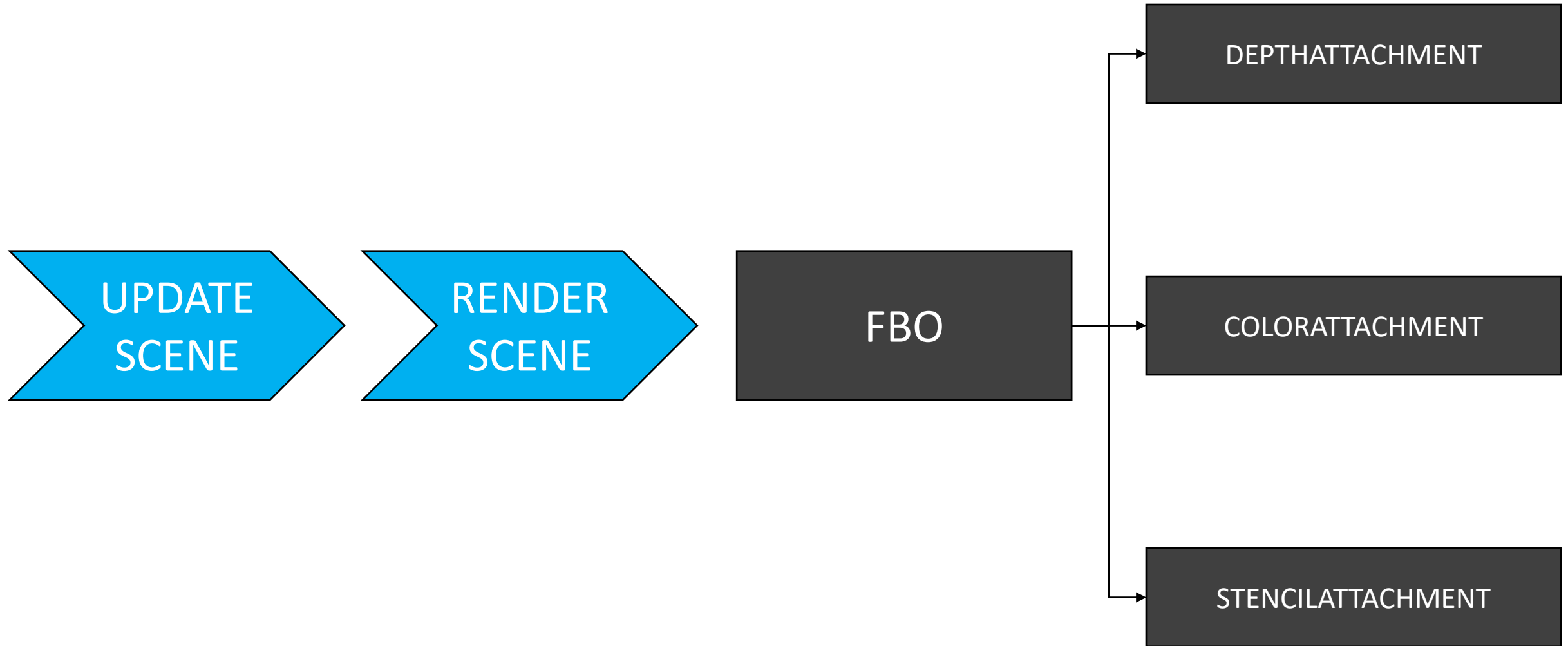
AUFBAU: FRAMEBUFFER



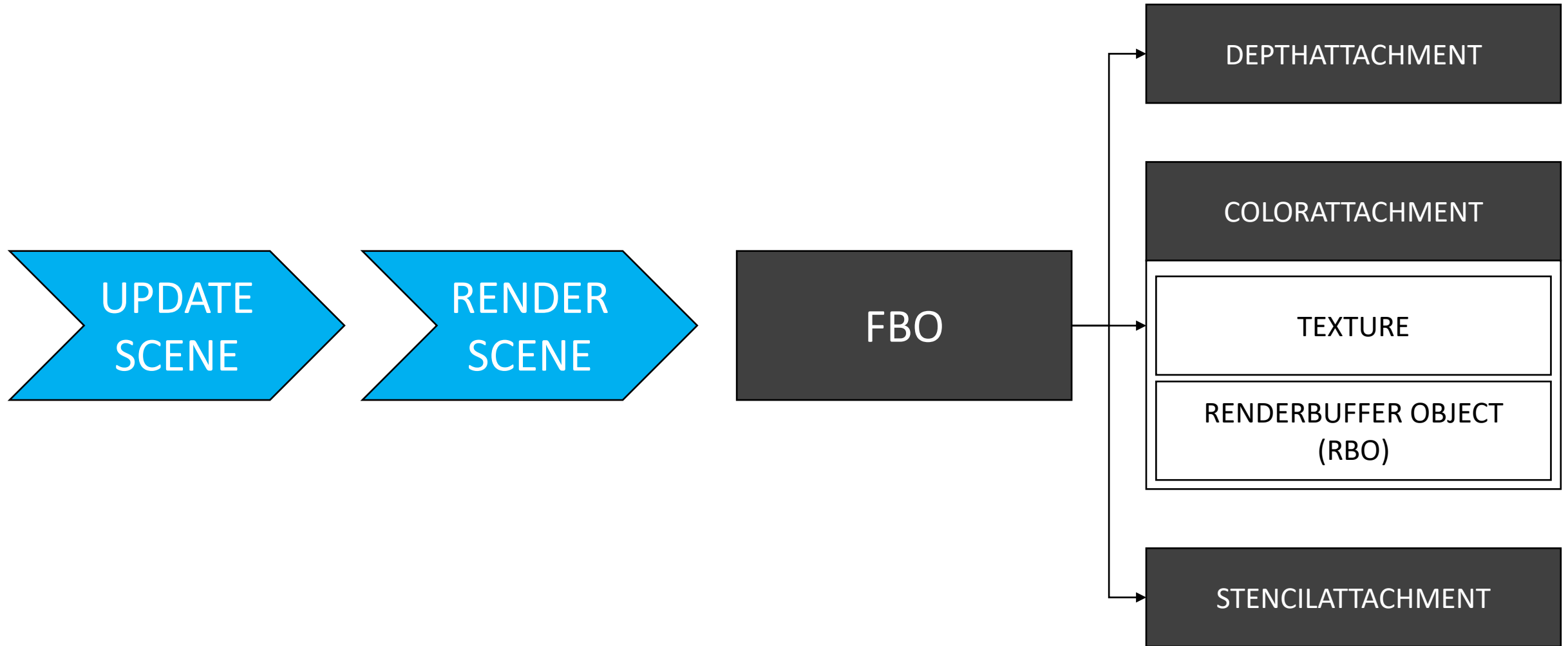
AUFBAU: FBO



AUFBAU: FBO

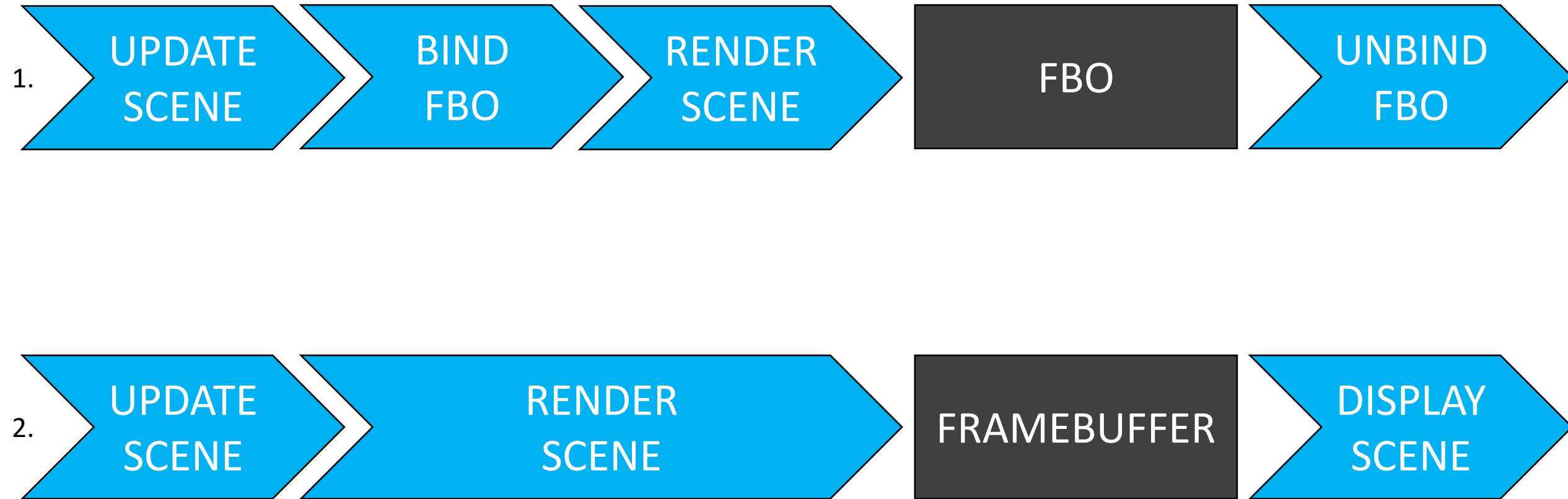


AUFBAU: FBO

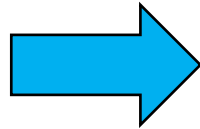
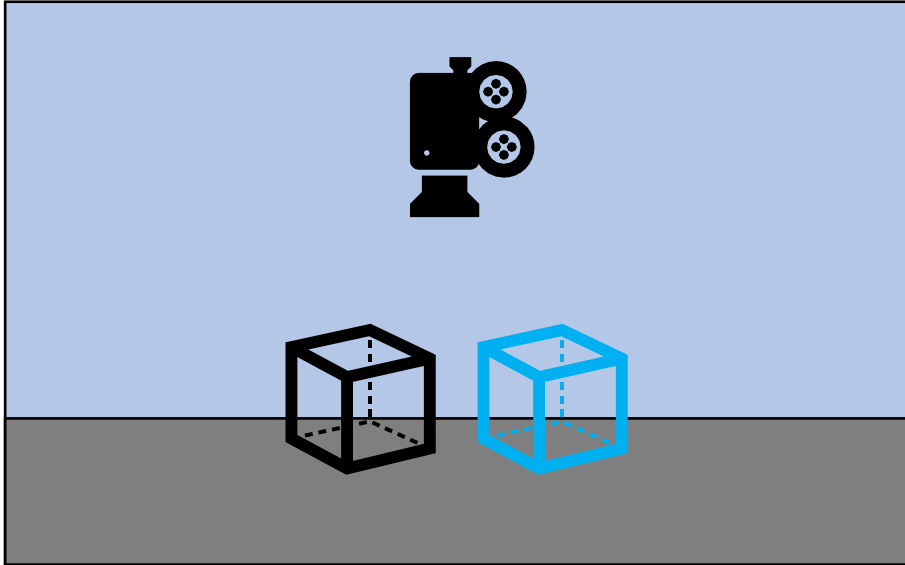


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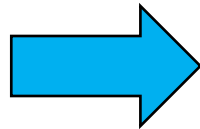
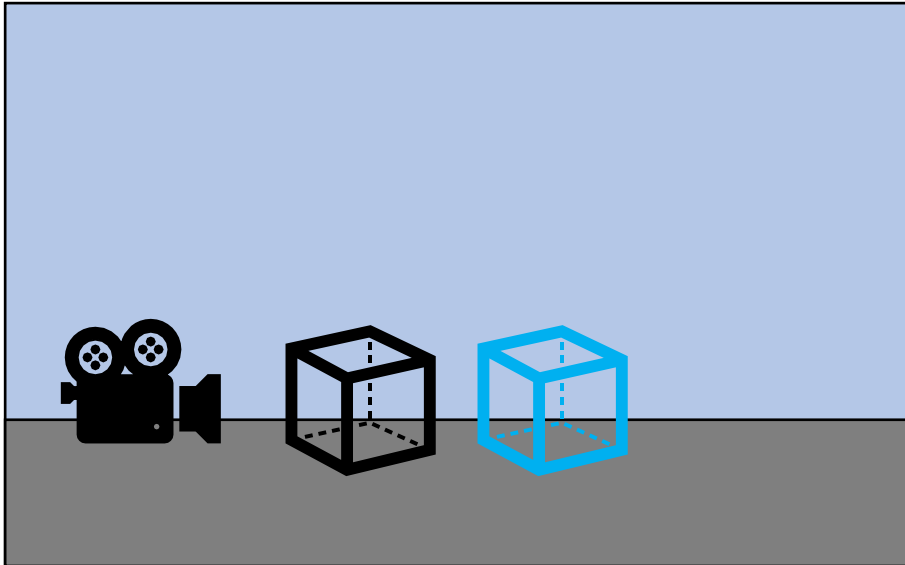
MOTIVATION



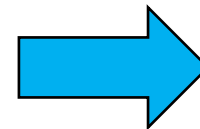
MOTIVATION



FBO

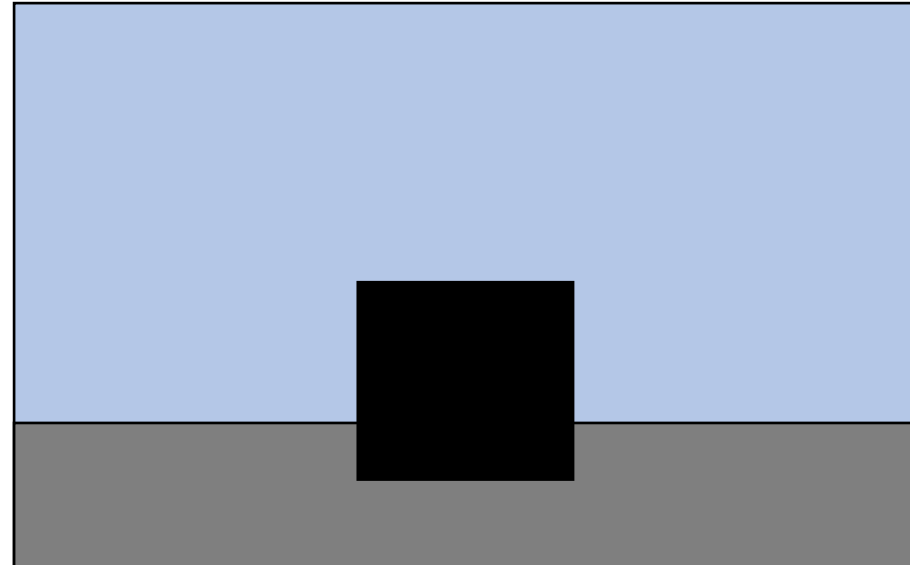
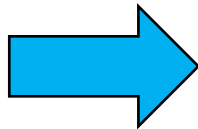
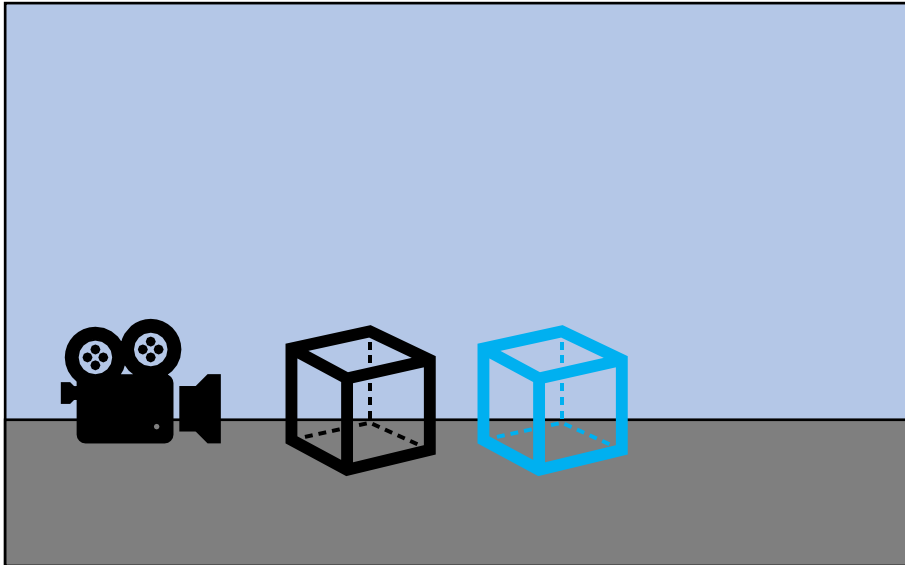
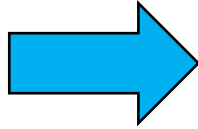
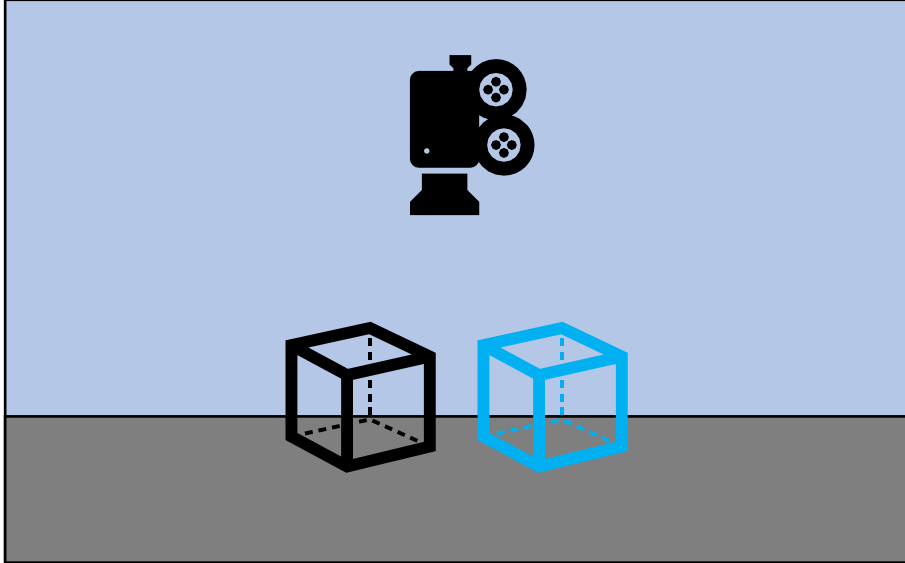


FRAMEBUFFER

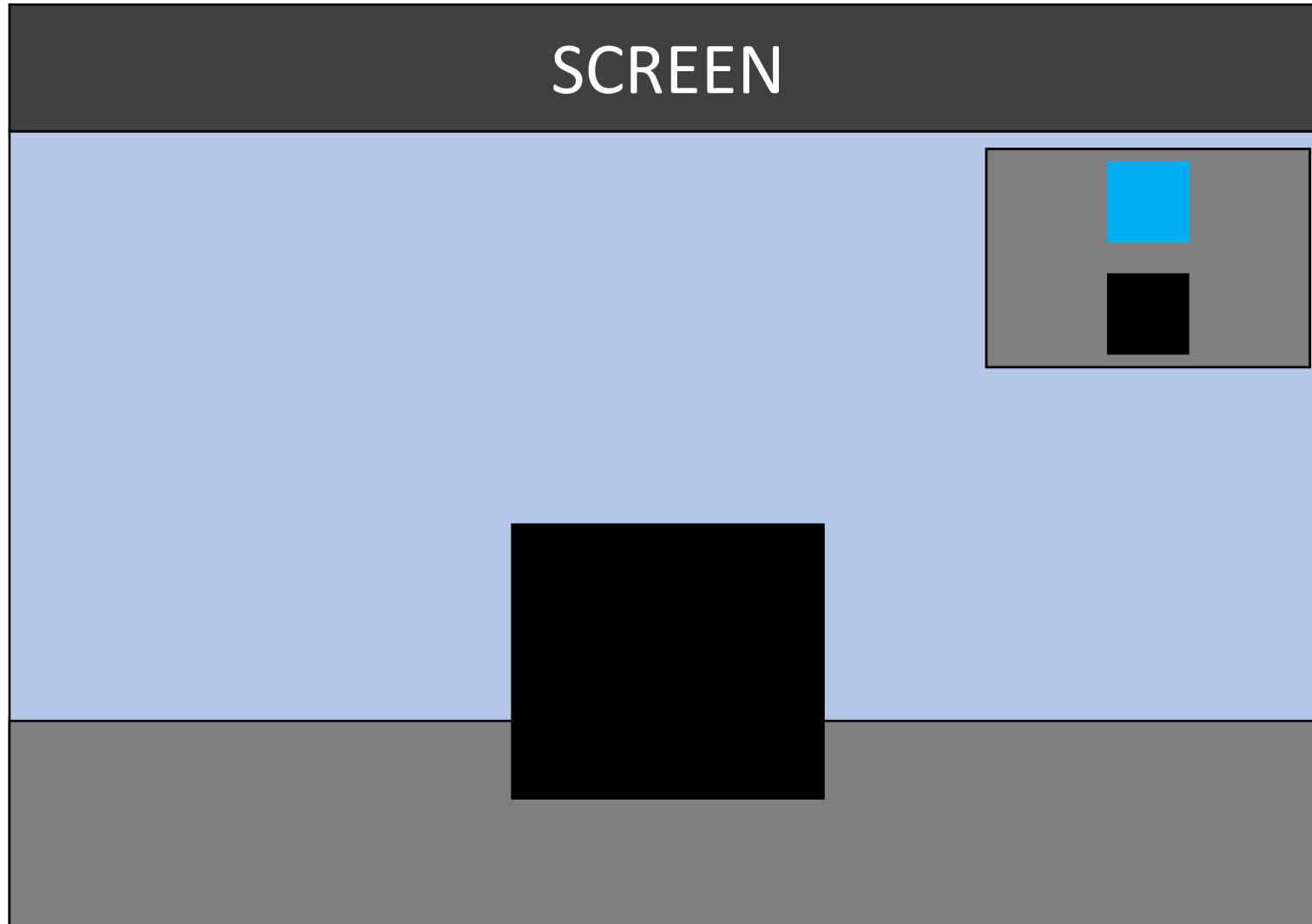


SCREEN

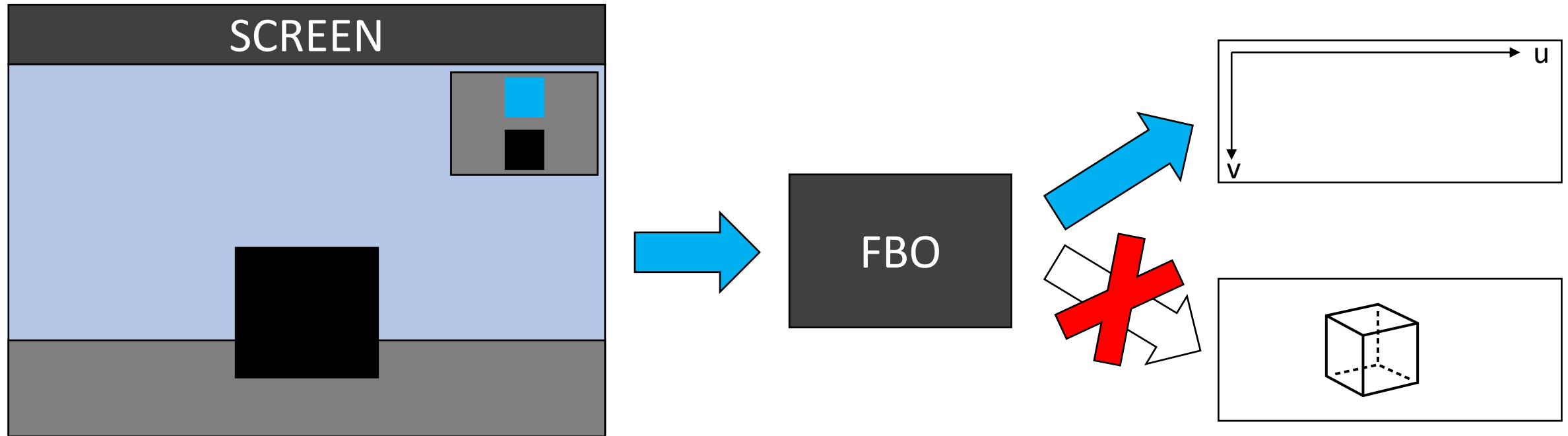
MOTIVATION



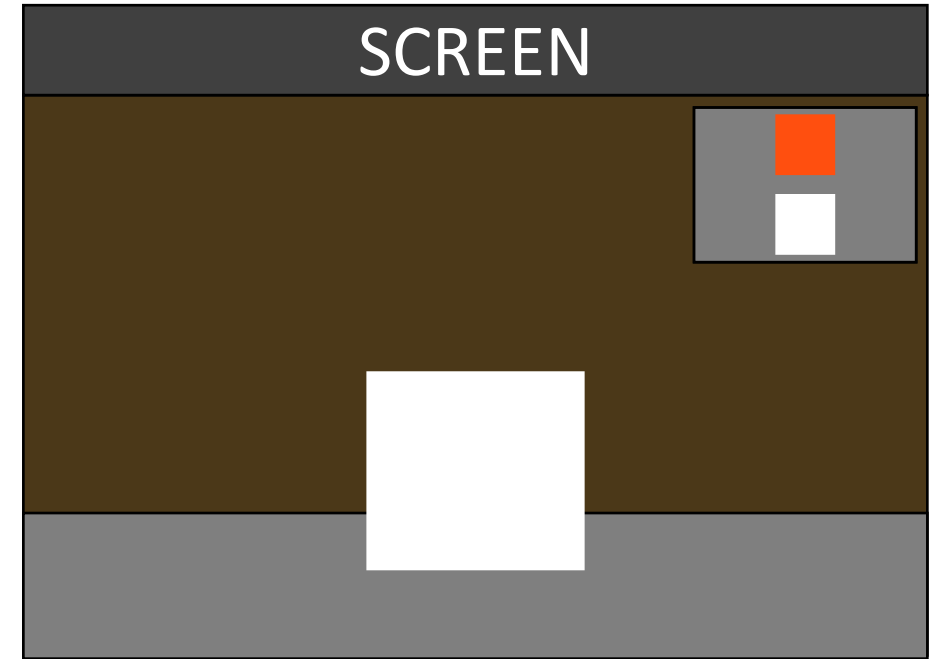
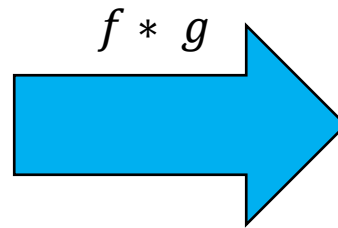
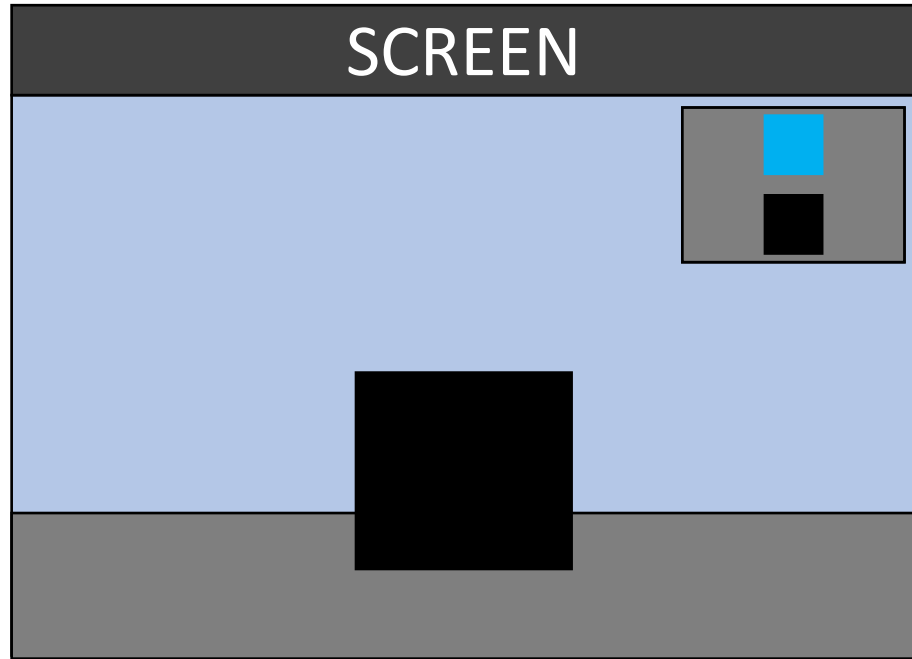
MOTIVATION



MOTIVATION - POSTPROCESSING



MOTIVATION



- Aufbau eines FBO
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- Livedemo : IBL

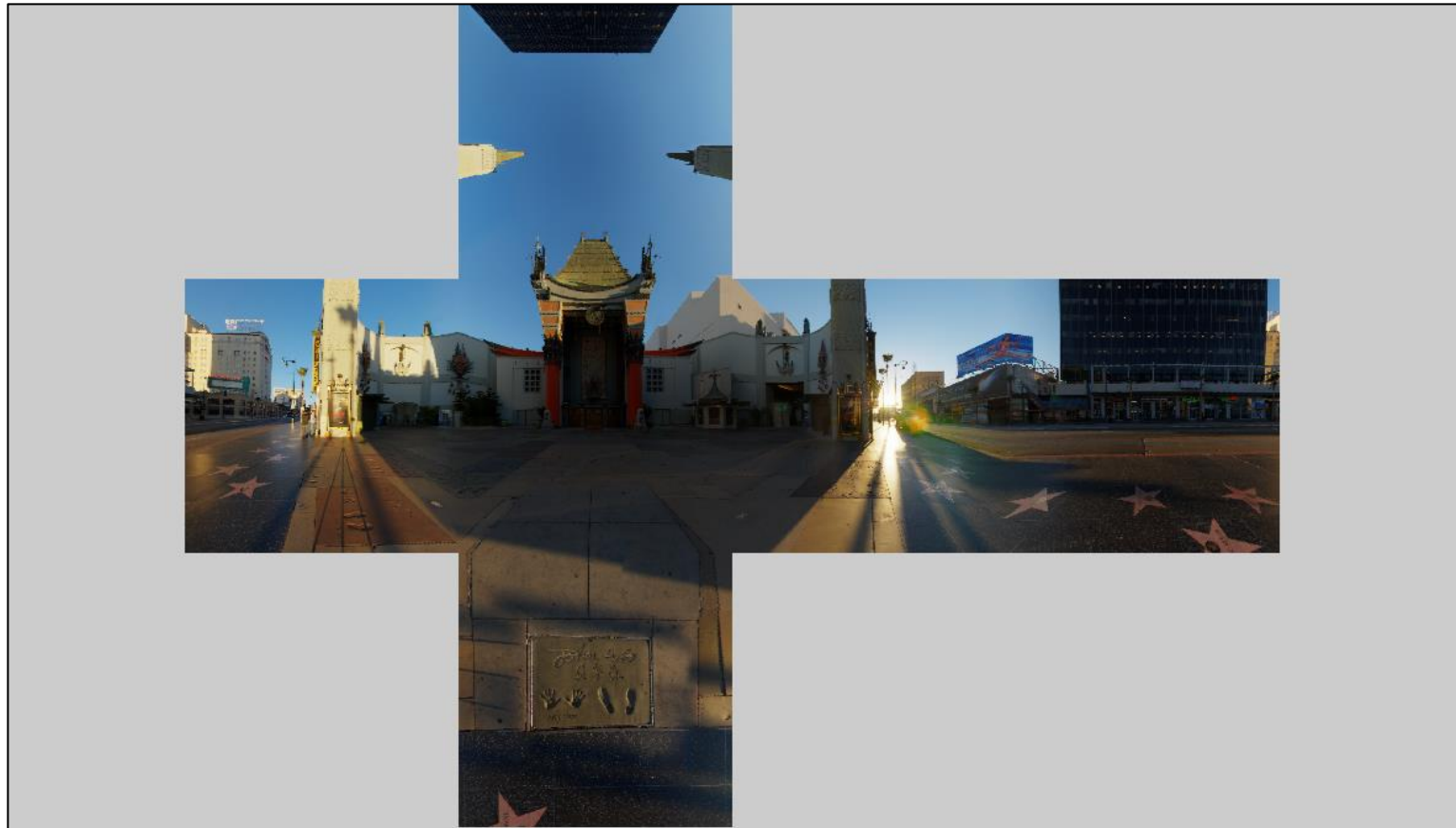
LIVEDEMO (FBO)

- Aufbau eines FBO
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- Livedemo : IBL

ANWENDUNGSBEISPIEL: IMAGE-BASED LIGHTING (IBL)

GRUNDIDEE

- Ersetzen der Lichtquellen durch Umgebungsmap



Quelle: [Skyboxes]

MOTIVATION

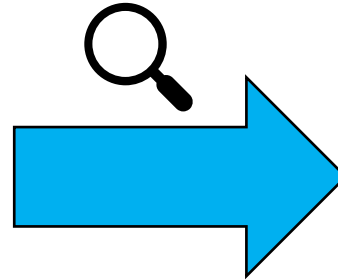
- Einsatz von PBR möglich => realistische Beleuchtung
- Komplexe Licht-Szene erstellen durch Bildaufnahme
- Auslesen des Lichtwerts aus vorberechneter Lookup-Table, statt Berechnung zur Laufzeit

KONVERTIERUNG

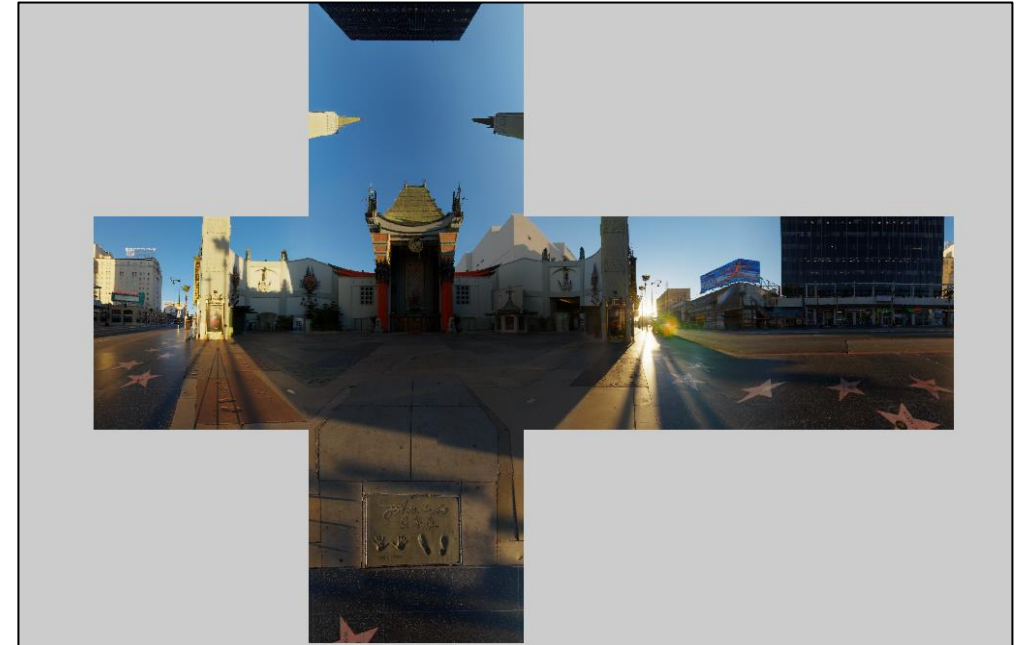
Equirectangular-Map



Quelle: [Skyboxes]



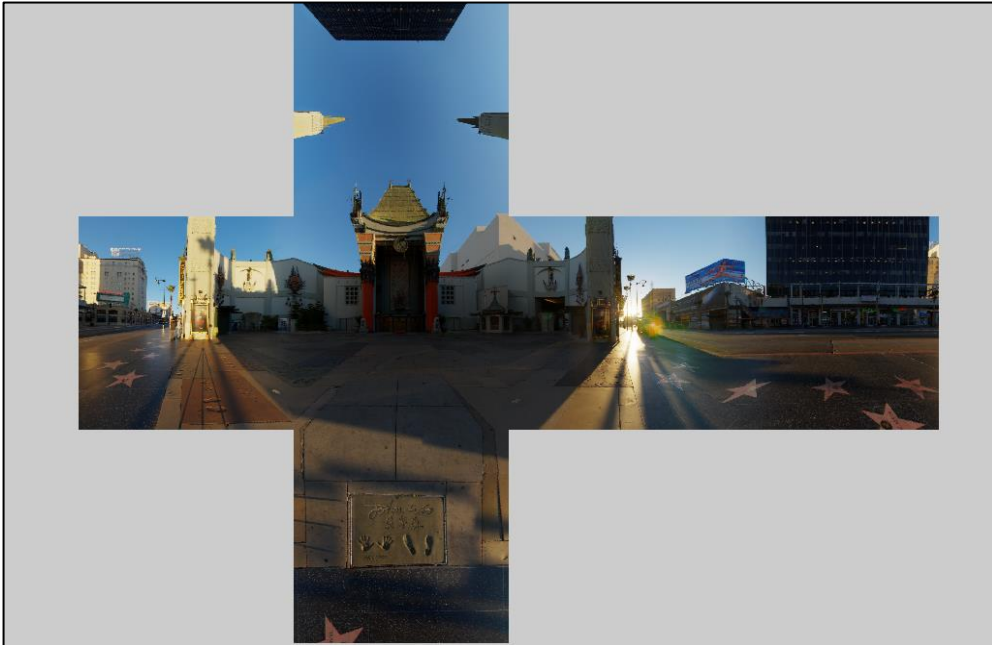
Skybox/Cubemap



Quelle: [Skyboxes]

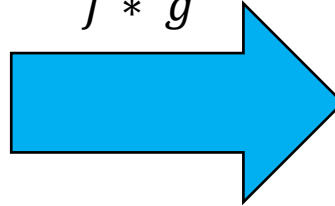
KONVERTIERUNG

Skybox/Cubemap

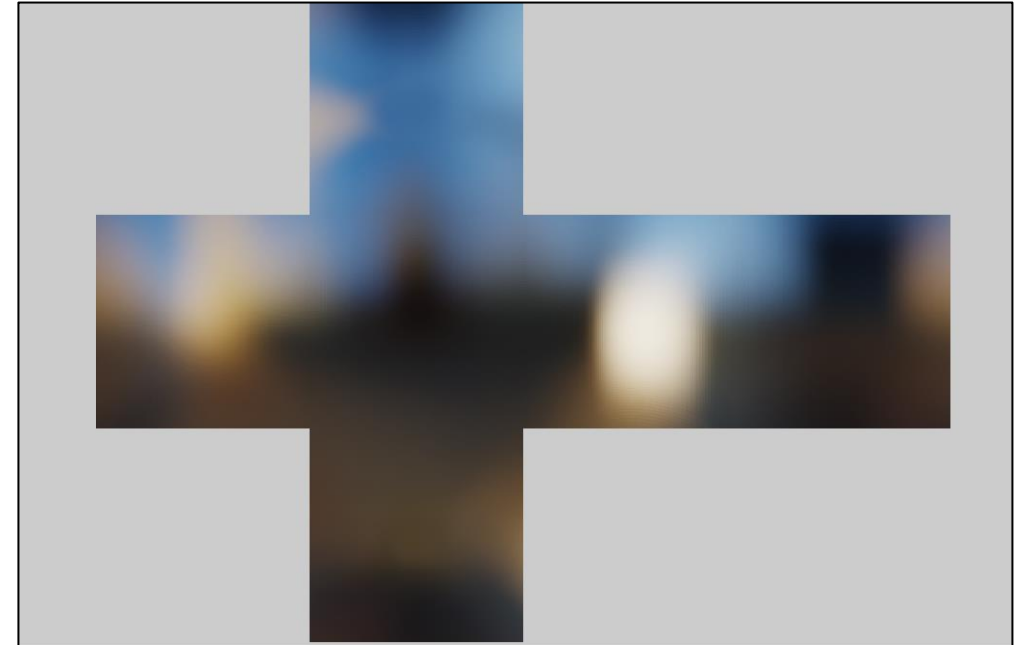


Quelle: [Skyboxes]

$$f * g$$



Irradiance-Map



Quelle: [Skyboxes]

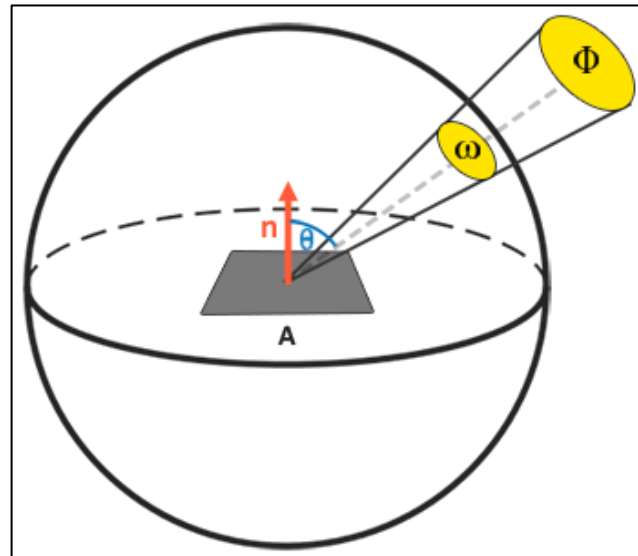
Cook-Torrance-Reflectance-Equation

$$L_o(p, \omega_o) = \int_{\Omega} \left(kd \cdot \frac{C}{\pi} + \frac{DFG}{4(\omega_o \cdot n) \cdot (\omega_i \cdot n)} \right) \cdot L_i(p, \omega_i) \cdot \cos(\theta_i) d\omega_i$$

$$L_o(p, \omega_o) = \underbrace{\int_{\Omega} \left(kd \cdot \frac{C}{\pi} \right) \cdot L_i(p, \omega_i) \cdot \cos(\theta_i) d\omega_i}_{\text{DIFFUSE}} + \underbrace{\int_{\Omega} \left(\frac{DFG}{4(\omega_o \cdot n) \cdot (\omega_i \cdot n)} \right) \cdot L_i(p, \omega_i) \cdot \cos(\theta_i) d\omega_i}_{\text{SPECULAR}}$$



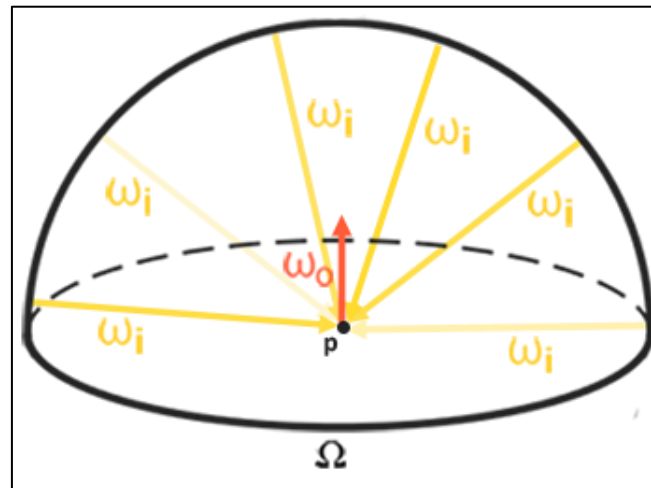
$$L_o(p, \omega_o) = \int_{\Omega} \left(kd \cdot \frac{C}{\pi} \right) \cdot L_i(p, \omega_i) \cdot \cos(\theta_i) d\omega_i$$



Quelle: [LearnOpenGL b]

THEORIE

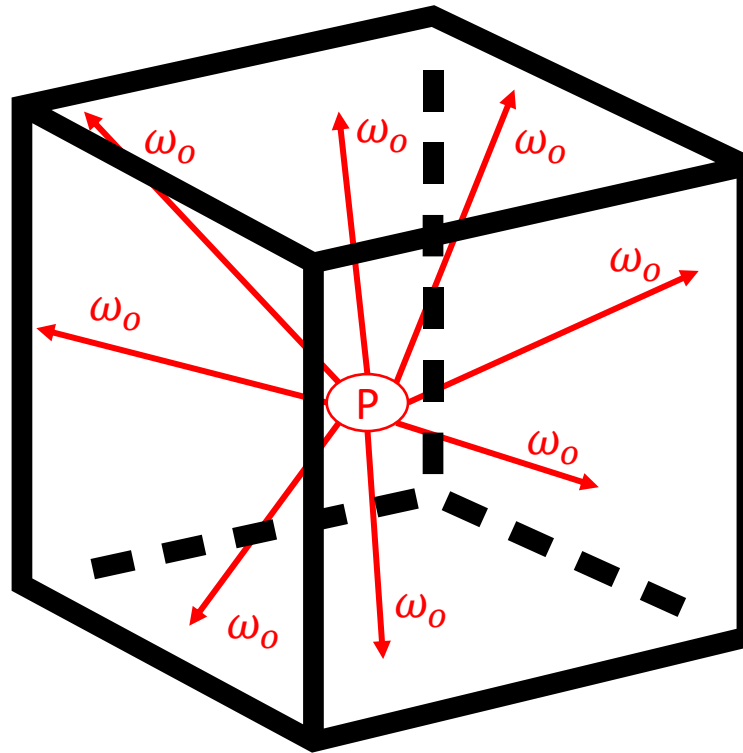
- Jeder Texel der Lookup-Table soll entsprechenden Lichtwert enthalten



Quelle: [LearnOpenGL a]

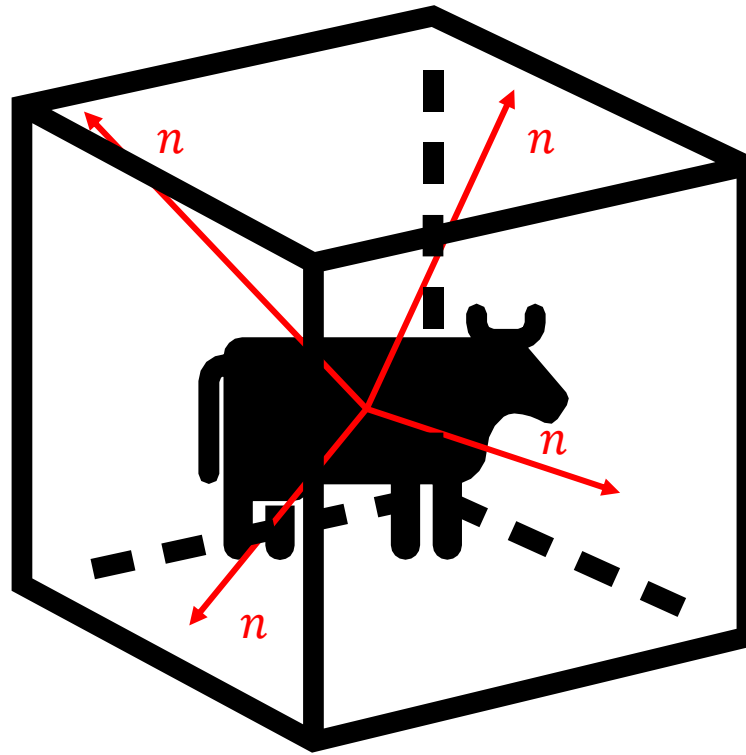
THEORIE

- Jeder Texel der Lookup-Table soll entsprechenden Lichtwert enthalten

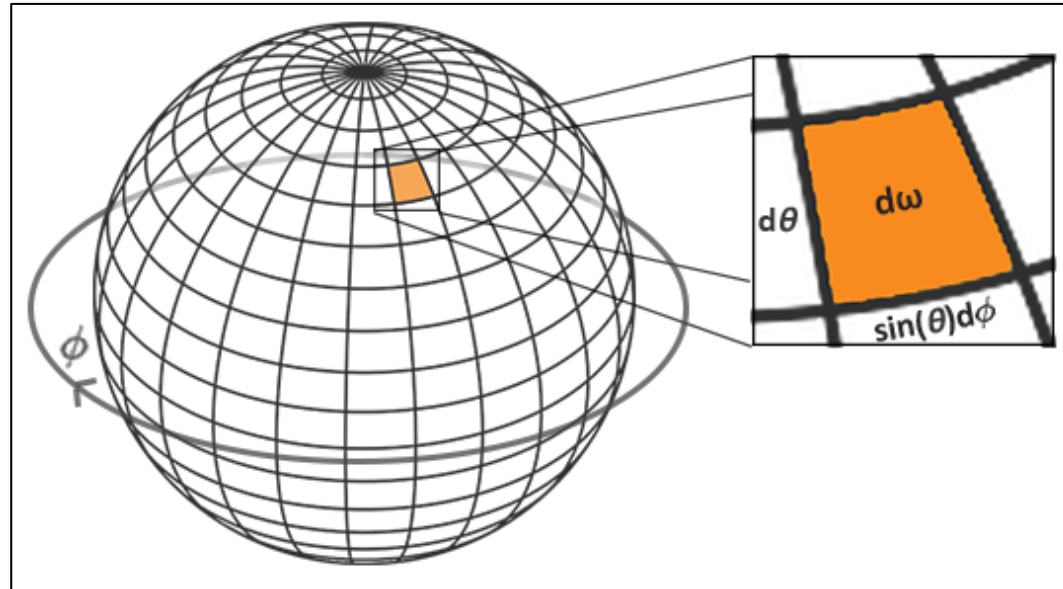


THEORIE

- Samplen der Texel über Normalen des Modells möglich => einfaches Auslesen



„Flächentrick“

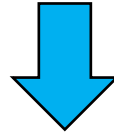


Quelle: [LearnOpenGL a]

ϕ entlang des „Äquators“: $[0; 2\pi]$
 θ entlang des „Nullmeridians“ zum Zenith: $[0; \frac{1}{2}\pi]$

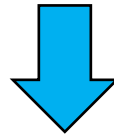
Original

$$L_o(p, \omega_o) = \int_{\Omega} \left(k_d \cdot \frac{c}{\pi} \right) \cdot L_i(p, \omega_i) \cdot \cos(\theta_i) d\omega_i$$



„Flächentrick“

$$L_o(p, \phi_o, \theta_o) = k_d \cdot \frac{c}{\pi} \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\frac{1}{2}\pi} L_i(p, \phi_i, \theta_i) \cos(\theta) \sin(\theta) d\phi d\theta$$



Riemannsumme

$$L_o(p, \phi_o, \theta_o) = k_d \cdot \frac{c\pi}{n_1 n_2} \sum_{\phi=0}^{n_1} \sum_{\theta=0}^{n_2} L_i(p, \phi_i, \theta_i) \cos(\theta) \sin(\theta) d\phi d\theta$$

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LIVEDEMO (IBL)

Danke für eure Aufmerksamkeit



QUELLEN

- [Khronos a] „Framebuffer.“, o.V., OpenGL Wiki, 24.02.2020, <https://www.khronos.org/opengl/wiki/Framebuffer>, accessed 25.11.2020
- [Khronos b] „Default Framebuffer.“, o.V., OpenGL Wiki, 04.02.2019, https://www.khronos.org/opengl/wiki/Default_Framebuffer , accessed 25.11.2020
- [Khronos c] „Framebuffer Object.“, o.V., OpenGL Wki, 26.11.2020 , https://www.khronos.org/opengl/wiki/Framebuffer_Object, accessed 26.11.2020
- [LearnOpenGL a] „Diffuse irradiance.“, de Vries, Joey., 2020, <https://learnopengl.com/PBR/IBL/Diffuse-irradiance>, accessed 28.11.2020
- [LearnOpenGL b] „Theory“, de Vries, Joey., 2020, <https://learnopengl.com/PBR/Theory>, accessed 28.11.2020
- [Skyboxes]: <http://www.hdrilabs.com/sibl/archive.html>, accessed 26.11.2020
- [Wolff] “OpenGL 4 Shading Language Cookbook: Build high-quality, real-time 3D graphics with OpenGL 4.6, GLSL 4.6 and C++17”, Wolff, David. 2018. 3rd Edition. Packt Publishing.