



POLITECNICO
MILANO 1863

The Dark Knight's Quest for Justice – Computer Graphics

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Game Concept

Game Name: The Dark Knight's Quest for Justice

Background: In a city torn between light and shadow, Batman is on a mission to track down his nemesis—the Joker. With chaos and fear spreading through every corner, it's up to you to assist the Dark Knight in solving puzzles, following leads, and ultimately stopping the Joker's diabolical schemes!

How to play: In short, find the Joker in the dark with your flashlight, catch him, and ride home from the space station.

Game info:

1. It is a first - person game.
2. Press WASD to move back and forth, left and right.
3. R/F to move up and down.
4. The mouse can rotate 360°.
5. The H key switches the flashlight.
6. 1/2/3/4/5 switches the flashlight light color.
7. Key 9/0 switches the scene position.
8. M can switch the perspective.



Model and Texture loading and initialize:

Description: Loaded diverse 3D models and high-quality textures.

Application: Enriching scene visuals with realistic models and textures.

I have used 16 objects and textures. These files represent a mix of characters, vehicles, environments, and props, forming the core components of the game's immersive 3D scenes.

1.**Park.obj** - Parking lot scene.

2.**TeslaCar.obj** - Tesla car.

3.**FordGT.obj** - Ford GT sports car.

4.**BenzAMGCLA.obj** - Mercedes-Benz AMG CLA.

5.**Lamborghini2023.obj** - Lamborghini 2023 model.

6.**Ferrari01.obj** - Ferrari sports car.

7.**Landrover2023.obj** - Land Rover 2023 model.

8.**Lamborghini2019.obj** - Lamborghini 2019 model.

9.**Maserati2024.obj** - Maserati 2024 model.

10.**Batman.obj** - Batman character model.

11.**Satellite.obj** - Satellite hands model.

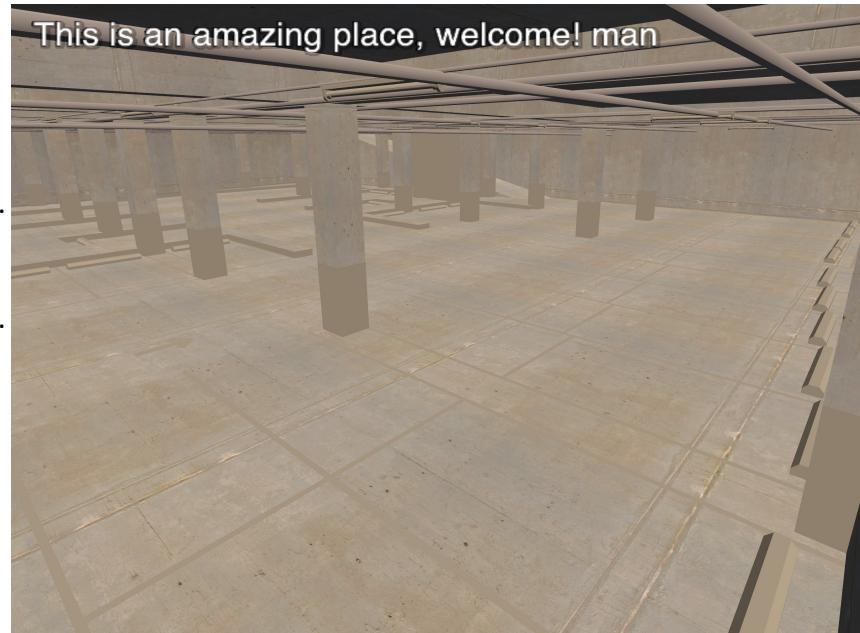
12.**Joker2.obj** - Joker character model.

13.**Spaceshuttle.obj** - Space shuttle model.

14.**Sphere.obj** - Sphere used for the Sun.

15.**SkyBoxUni2.obj** - Skybox environment.

16.**AK47.obj** - AK47 weapon model to be FP.



Statistics

- Total Count: 16 objects.**

- Main Character Models:** Batman, Joker.

- Vehicle Models:** 8 files (e.g., Tesla, Ford GT, Lamborghini).

- Environment Models:** 3 files (Parking lot, skybox, Sun).

- Prop Models:** 1 file (AK47 weapon to be the First-person).

```
Loading : models/AK47.obj[OBJ]
[OBJ] Vertices: 195753 Indices: 195753
Loading : models/Sphere.obj[OBJ]
[OBJ] Vertices: 2880 Indices: 2880
Loading : models/SkyBoxUni2.obj[OBJ]
[OBJ] Vertices: 11904 Indices: 11904
Loading : models/Park.obj[OBJ]
[OBJ] Vertices: 181584 Indices: 181584
Loading : models/TeslaCar.obj[OBJ]
[OBJ] Vertices: 4242 Indices: 4242
Loading : models/FordGT.obj[OBJ]
[OBJ] Vertices: 4116 Indices: 4116
Loading : models/BenzAMGCLA.obj[OBJ]
[OBJ] Vertices: 4560 Indices: 4560
Loading : models/Lamborghini2023.obj[OBJ]
[OBJ] Vertices: 4428 Indices: 4428
Loading : models/Ferrari01.obj[OBJ]
[OBJ] Vertices: 4596 Indices: 4596
Loading : models/Landrover2023.obj[OBJ]
[OBJ] Vertices: 4236 Indices: 4236
Loading : models/Lamborghini2019.obj[OBJ]
[OBJ] Vertices: 6612 Indices: 6612
Loading : models/Maserati2024.obj[OBJ]
[OBJ] Vertices: 5058 Indices: 5058
Loading : models/Satellite1.obj[OBJ]
[OBJ] Vertices: 141972 Indices: 141972
Loading : models/Batman.obj[OBJ]
[OBJ] Vertices: 52542 Indices: 52542
Loading : models/Joker2.obj[OBJ]
[OBJ] Vertices: 2999850 Indices: 2999850
Loading : models/Spaceshuttle.obj[OBJ]
[OBJ] Vertices: 3430332 Indices: 3430332
[0]textures/AK47.jpeg -> size: 4096x4096, ch: 3
[0]textures/2k_sun.jpg -> size: 2048x1024, ch: 3
[0]textures/galaxystars.jpg -> size: 6000x6000, ch: 3
[0]textures/constellation_figures.png -> size: 4096x2048, ch: 3
[0]textures/ground.jpg -> size: 4096x4096, ch: 3
[0]textures/Tesla.jpeg -> size: 4096x4096, ch: 3
[0]textures/FordGTy.jpg -> size: 4096x4096, ch: 3
[0]textures/BenzAMGCLA.jpg -> size: 4096x4096, ch: 3
[0]textures/Lamborghini2023.png -> size: 4096x4096, ch: 4
[0]textures/Ferrari01.jpeg -> size: 2048x2048, ch: 3
[0]textures/Landrover2023.jpeg -> size: 2048x2048, ch: 3
[0]textures/Lamborghini2019.jpg -> size: 4096x4096, ch: 3
[0]textures/Maserati2024.jpeg -> size: 4096x4096, ch: 3
[0]textures/CityPark.jpeg -> size: 2048x512, ch: 3
```

Camera and Uniform buffer objects setting

Uniform Buffer Objects (UBOs)

- **Description:** Used UBOs to efficiently pass global variables and object-specific parameters.
- **Application:** Dynamic updates for lighting, camera positions, and object transformations.

In order to build the game scene and place the introduced objects according to the game design concept, I spent a lot of time in this part to modify the specific position, rotation Angle and size of each obj object, and finally successfully built such a parking lot.



Dynamic Camera Control

- **Description:** Supported dynamic camera movement and perspective changes, including switching between orthographic and perspective views.
 - **Application:** Creating immersive first-person and third-person experiences.
- A first-person perspective camera is designed, and an AK47 gun is bound as the weapon of the character. Following the first-person perspective camera, the light of the flashlight can also follow the first-person movement of the character, successfully realizing the game concept of using the flashlight to explore in the dark.



Shader

I used 5 Shders in my game:

1. BlinnShader.frag

•**Purpose:** Implements the Blinn-Phong lighting model combined with flashlight effects. It includes diffuse, specular, and ambient lighting calculations.

•**Key Features:**

- Uses textures for diffuse and ambient contributions.
- Adds Gaussian-based spotlight control for dynamic lighting effects.
- Provides realistic reflections and light falloff.

2. TextShader.frag

•**Purpose:** Handles text rendering with color customization for foreground, background, and shadows.

•**Key Features:**

- Red channel determines the intensity of text rendering.
- Offers transparent background and shadow blending.

3. SkyBoxShader.frag

•**Purpose:** Renders a skybox with combined effects from two texture layers.

•**Key Features:**

- Computes yaw and pitch to map textures accurately to a spherical environment.
- Blends primary skybox and star textures for a dynamic sky effect.

4. ToonShader.frag

•**Purpose:** Implements a toon-shading effect for stylized visuals.

•**Key Features:**

- Divides lighting intensity into discrete levels for a cartoon-like appearance.
- Combines ambient, diffuse, and specular components with flashlight effects.
- Adjustable light intensity and Gaussian flashlight control.

5. EmitShader.frag

•**Purpose:** Handles emissive materials, providing glowing effects for objects.

•**Key Features:**

- Uses textures to define emissive properties.
- Outputs a constant ambient glow based on the texture.



Shader effects displayed

Here, we can see the effects of Textshader. When I didn't turn on the flashlight, I simulated the graphic rendering of human eyes, and when we turned on the flashlight, on the parking level, Implemented a toon-shading effect for stylized visuals for all objects(except the AK47 and Joker).



Human vision without light in the dark

Flashlight effects

Toon-shading effects

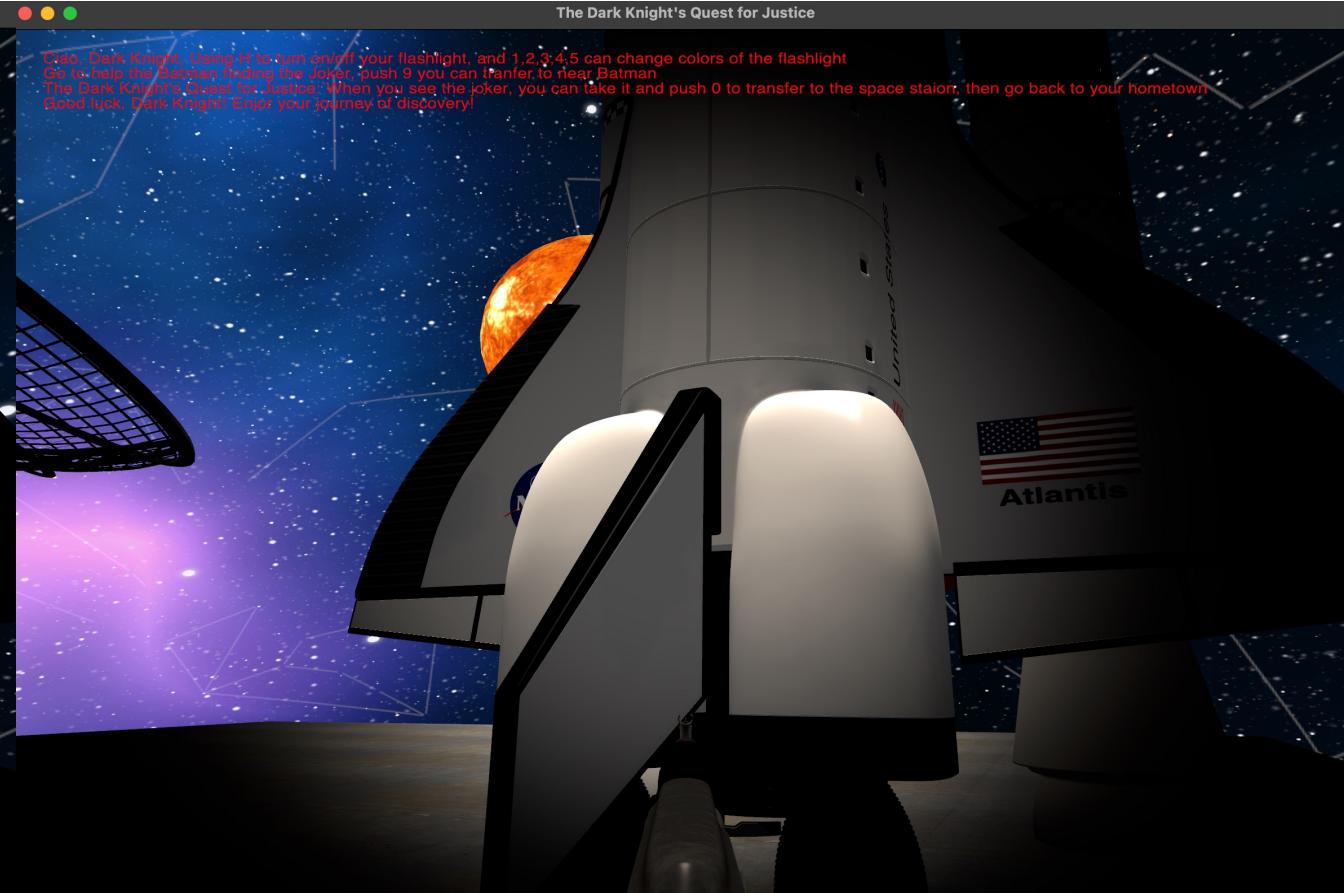


Shader effects displayed

In the space station layer, we can see the use of skyboxshader and EmitShader to achieve a dynamic skybox and a forever glowing sun. All other objects are bound to the Blinn-Phong lighting model shader. It includes diffuse, specular, and ambient lighting calculations (without Toon effects).



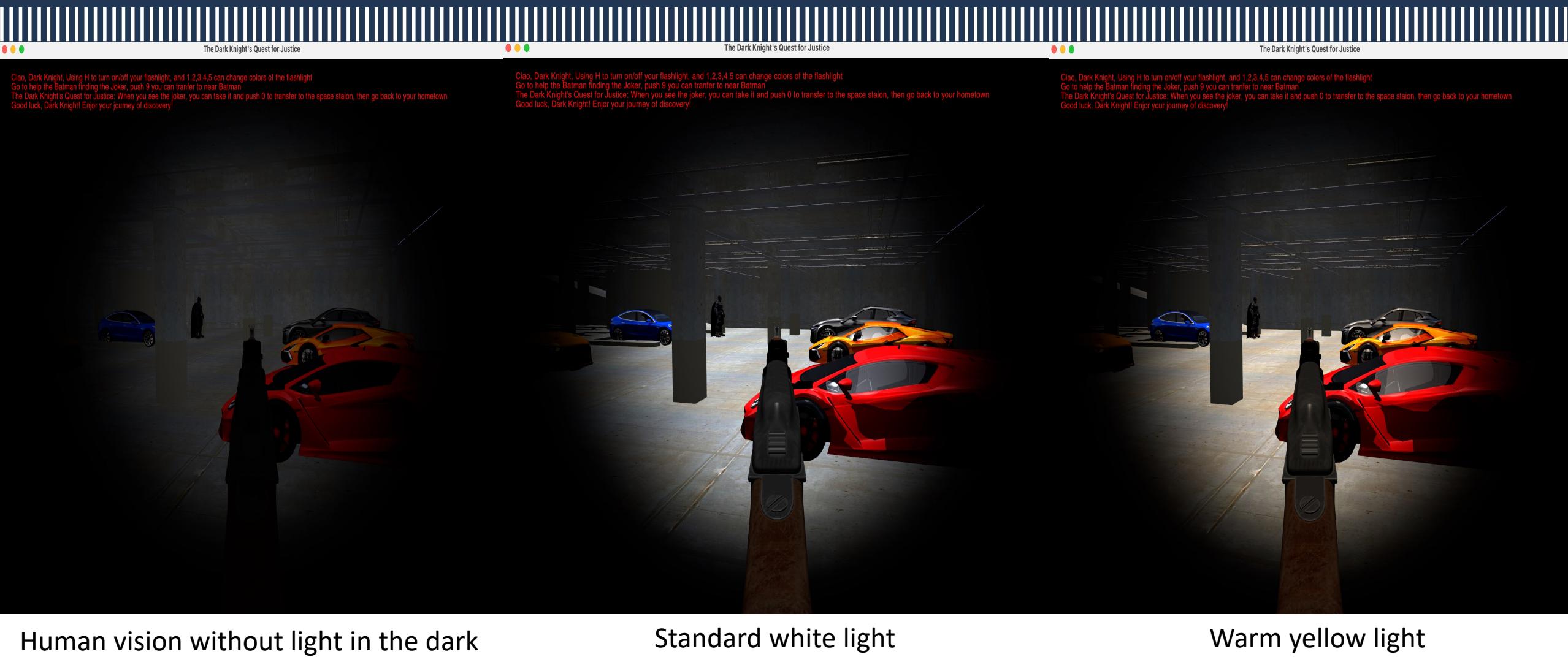
Human vision without light in the dark



Blinn-Phong lighting model shader effects



Different color



Human vision without light in the dark

Standard white light

Warm yellow light



Different color



Cold blue light

Pale green light

red light



Main Characters in different light effects– Batman and Joker



Ciao, Dark Knight. Using H to turn on/off your flashlight, and 1,2,3,4,5 can change colors of the flashlight
Go to help the Batman finding the Joker, push 9 you can transfer to near Batman
The Dark Knight's Quest for Justice: When you see the joker, you can take it and push 0 to transfer to the space station, then go back to your hometown
Good luck, Dark Knight! Enjoy your journey of discovery!



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Human vision without light in the dark

Standard white light

Pale green light



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Human vision without light in the dark



Standard white light



red light



Summary

In this project, I used Vulkan to build some really cool 3D environments with high-performance rendering. I worked on advanced lighting and shadow effects, like global illumination and spotlights, which make the scene feel more alive and interactive.

I also used MVP matrix transformations to control how objects move, rotate, and scale in the world. To make everything look even better, I created multiple shader pipelines for different models, which helped achieve both realistic and cartoon-like visuals, and made 5 different colors of flashlight.

I added interactive features too, like keyboard controls for switching lights and teleporting, so players can really engage with the environment. Plus, I managed materials using uniform buffer objects and textures, making sure everything renders smoothly.

And to top it off, I included text rendering to give players real-time instructions and overlays, making the whole experience more user-friendly.





Thank you for your attention

