# Project Documentation: Cube Rotation Visualization (Part A) 🗐

## Overview 👀

This project is a Qt-based OpenGL application that renders a 3D cube with an animated magma texture. It provides a menu-driven interface to interact with the cube via several features:

1. **Line Rotation** ✏️
   - **What it does**: Lets the user specify a line defined by a point **b** and a direction vector **d** along with a rotation angle (α).
   - **How it's implemented**:
     - A dialog (LineRotationDialog) collects the parameters.
     - The cube is rotated using the transformation:
       `M = T(+b) * R(α, normalized(d)) * T(-b) * M_current`
     - The dialog is pre-populated with default values based on the current state.

2. **View Position** 🎯
   - **What it does**: Allows the user to change the camera position (eye) and the point the camera is looking at.
   - **How it's implemented**:
     - A dialog (ViewPositionDialog) collects the eye and target coordinates.
     - The view matrix is updated using a `lookAt` transformation.

3. **Default Position** 🔄
   - **What it does**: Resets the view to its default state (camera at (0,0,3) looking at the origin).
   - **How it's implemented**:
     - The `resetDefault()` method sets the view matrix and resets the model matrix.

4. **Animation** ⏩
   - **What it does**: Toggles an automatic rotation of the cube around the Y-axis.
   - **How it's implemented**:
     - A QTimer triggers continuous rotation updates.

5. **Texture Animation** 🔥
   - **What it does**: Cycles through three phases of the magma texture every 700ms.
   - **How it's implemented**:
     - The 16×48 texture is split into three 16×16 sub-images.
     - A timer cycles through these textures.

6. **Gloss Effect Toggle** ✨
   - **What it does**: Applies a gloss (specular highlight) effect on bright areas of the texture.
   - **How it's implemented**:

    - The fragment shader uses a `smoothstep` between brightness thresholds (values corresponding to colors #CA4E06 and #F89E44) to compute a specular component.
    - A toggle in the menu enables/disables the effect via a uniform (`uGlossOn`).

7. **Zoom & Manual Rotation** 🔍 🖱️

    - **What it does**:
        - **Zoom**: The mouse wheel adjusts the camera distance.
        - **Manual Rotation**: Clicking and dragging rotates the cube manually (disabling automatic animation).
    - **How it's implemented**:
        - The `wheelEvent()` updates the view matrix.
        - Mouse events compute rotation deltas to update the model matrix.

8. **Window Icon & Background** 🎨

    - **What it does**: Sets a custom window icon and background color (#456990).
    - **How it's implemented**:
        - The MainWindow uses `setWindowIcon(QIcon(":/textures/textures/mine.png"));`.
        - In `initializeGL()`, `glClearColor(0.27f, 0.41f, 0.56f, 1.0f);` is called to set the background.

## Architecture and Implementation Details 🛠️

- **Project Structure**:

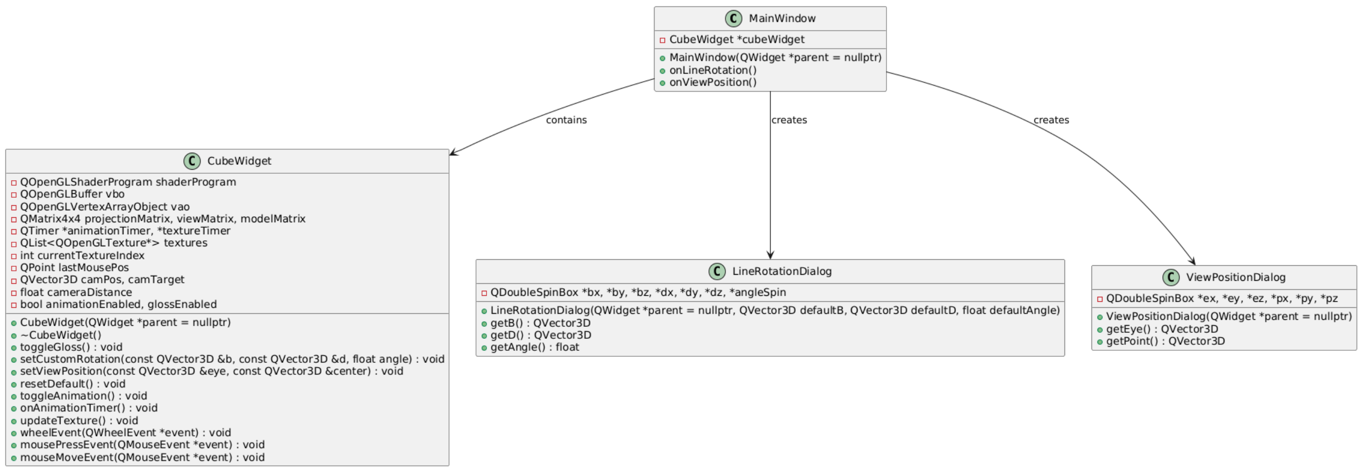
    - The application is built using Qt Widgets and QOpenGLWidget.
    - All texture and icon files are managed using the Qt resource system (.qrc).

- **Rendering Pipeline**:

    - **Vertex Data**:
      Each vertex includes 8 floats: position (vec3), normal (vec3), and texture coordinates (vec2).
    - **Shaders**:
      Custom GLSL shaders implement Phong lighting (ambient, diffuse, specular) and a configurable gloss effect.
    - **Uniforms**:
      Various uniforms control transformations, lighting parameters, and the gloss toggle.

## Visual Architecture Diagram 📊

Below is a sample PlantUML diagram representing the project structure:


MainWindow
- CubeWidget *cubeWidget
+ MainWindow(QWidget *parent = nullptr)
+ onLineRotation()
+ onViewPosition()
contains
creates
creates
CubeWidget
- QOpenGLShaderProgram shaderProgram
- QOpenGLBuffer vbo
- QOpenGLVertexArrayObject vao
- QMatrix4x4 projectionMatrix, viewMatrix, modelMatrix
- QTimer *animationTimer, *textureTimer
- QList<QOpenGLTexture*> textures
- int currentTextureIndex
- QPoint lastMousePos
- QVector3D camPos, camTarget
- float cameraDistance
- bool animationEnabled, glossEnabled
+ CubeWidget(QWidget *parent = nullptr)
+ ~CubeWidget()
+ toggleGloss() : void
+ setCustomRotation(const QVector3D &b, const QVector3D &d, float angle) : void
+ setViewPosition(const QVector3D &eye, const QVector3D &center) : void
+ resetDefault() : void
+ toggleAnimation() : void
+ onAnimationTimer() : void
+ updateTexture() : void
+ wheelEvent(QWheelEvent *event) : void
+ mousePressEvent(QMouseEvent *event) : void
+ mouseMoveEvent(QMouseEvent *event) : void
LineRotationDialog
- QDoubleSpinBox *bx, *by, *bz, *dx, *dy, *dz, *angleSpin
+ LineRotationDialog(QWidget *parent = nullptr, QVector3D defaultB, QVector3D defaultD, float defaultAngle)
+ getB() : QVector3D
+ getD() : QVector3D
+ getAngle() : float
ViewPositionDialog
- QDoubleSpinBox *ex, *ey, *ez, *px, *py, *pz
+ ViewPositionDialog(QWidget *parent = nullptr)
+ getEye() : QVector3D
+ getPoint() : QVector3D