Tanmay Haldankar, Sanchit Kedia, Qamar Syed
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Project Proposal: KUKA KR5 Path Planner

Our project for Acme Robotics will consist of a path-planning module for the KUKA KR5. The KUKA KR5 is a popular robot arm used in many industries and applications. It is a manipulator arm, consisting of 6 rotating joints which can move a tooling end around within a radius of 855 mm. The module designed will take an input of the desired tooling position for the robot and return the joint positions required to obtain this position. This feature is crucial for developing programs for 6-axis manipulator arms. When installing these arms for tasks, users of the robot will want to move the robot tool around to fulfill whatever task they have. Although they could select all the joint positions across the entire program, this would make the programming much more time consuming and significantly less user-friendly. The module proposed should allow for users to develop robot paths without needing to individually plan out each joint.

The team members for this project are Tanmay Haldankar, Sanchit Kedia, and Qamar Syed. Tanmay and Sanchit will employ pair programming and take the role of the two primary developers for this project. Qamar will be an additional developer, but mainly has the responsibility of design keeper. He will ensure that the project is following the UML design and be an additional navigator for the driver-navigator pair. Developers will log their hours and tasks worked on to document the Agile process. This project will also employ test-driven development, in which the software will be designed to pass a set of initially created tests.

The development of this project will follow the Agile iterative process. Before development, the group will create UML diagrams and other supporting documentation to outline the design and general plan for the project. This will be followed by two week-long Agile iterations of development. Before each iteration, the team will determine and log tasks for that iteration. Daily commits will be performed along with frequent communication to ensure the project is completed successfully and on time.

The project will be developed in C++ 14 and the developers will be utilizing VSCode. Travis will be used to assist with continuous integration. The build will be done using CMake and Make and the project will be compiled using gcc. Other than the standard C++ library, the only library needed will be Eigen. Boost is a common library for linear algebra applications and matrix math, which will be important to this project. Eigen falls under the Mozilla Public License, which is free and open source. There should be no issues in using it for this application.

Robot kinematics are split into two types, inverse and forward. Forward kinematics is relatively straightforward and simply calculates the tooling position based on the positions of the joints. Inverse kinematics does the opposite, and calculates joint positions based on a desired tool position. The KUKA KR5 is a 6-axis arm with a spherical wrist. Since the number of degrees of freedom (3 cartesian plus 3 rotational axes) is equal to the number of joints (6), an analytical solution is possible.

The approach begins with inverse kinematics, in which a transformation matrix is made based upon the given coordinate. Since the wrist of this robot is spherical, the procedure for inverse kinematics can be split into two parts, which each solve for three robot joints. This is then followed by the DH method for forward kinematics, in which the robot parameters and

angles are used to generate a DH matrix, which then solves for the desired end effector location based on given joint values.

There are not many risks or unknowns involved with this project; most of the implementation will be engineered by our development team and the fundamental concepts are fairly straightforward so the reliance on external factors or the quality of code from outside the team is very little. Within the team, the only present risks are some difficulty with the technical content of the project as it is fairly new to the group members, and properly implementing the Agile development process into fairly busy schedules, but these are not of huge concern.

The final deliverables for this project will be a GitHub repository with all the source and test files, a video demonstrating the module, UML diagrams, and documents for our implementation of the Agile process.