Requirements for Autonomous Robot Development with Jetson Nano

1 Hardware Requirements

1. **Jetson Nano Developer Kit**
   - The system shall include a Jetson Nano module.
   - The system shall have a power supply of 5V 4A.
   - The system shall have a MicroSD card with a minimum capacity of 32GB.
   - The system may include a USB Wi-Fi adapter for wireless connectivity.
2. **Casing for Jetson Nano**
   - The system shall include a casing compatible with Jetson Nano dimensions.
   - The casing shall provide adequate ventilation for cooling.
   - The casing shall allow access to USB, HDMI, Ethernet, and Power ports.
3. **Cameras**
   - The system shall include two high-resolution camera modules compatible with Jetson Nano.
     - One camera shall be used for following the road.
     - The other camera shall be used for detecting plants.
   - The system shall have mounts for secure attachment of the cameras to the vehicle.
4. **Chassis and Motors**
   - The system shall use a 1:10 scale vehicle chassis.
   - The system shall include high-torque DC motors or servo motors for driving.

- The system shall include a motor driver compatible with Jetson Nano (e.g., L298N Motor Driver).

5. **Power Supply for Vehicle**
   - The system shall include a battery pack with appropriate voltage and capacity to power motors and Jetson Nano (e.g., 7.4V 5000mAh LiPo battery).
6. **Sensors**
   - The system shall use the cameras as the primary sensors.
   - The system may include additional sensors for enhanced navigation (e.g., ultrasonic sensors for obstacle detection).
7. **Other Components**
   - The system shall include wheels compatible with a 1:10 scale chassis.
   - The system shall include wiring and connectors.
   - The system shall include a breadboard and jumper wires for prototyping.
   - The system shall include mounting hardware for securing components.
   - The system shall include mechanisms for eliminating weeds and distributing fertilizer to healthy plants.

2 Software Requirements

1. **Operating System**
   - The system shall use a Linux-based OS compatible with Jetson Nano (e.g., JetPack SDK).
2. **Programming Environment**
   - The system shall use Python or C++ for development.
   - The system shall use OpenCV for image processing.
   - The system shall use TensorFlow or PyTorch for machine learning models.
3. **Libraries and Tools**
   - The system shall use ROS (Robot Operating System) for robot control.
   - The system shall use Jetson Inference for deploying AI models on Jetson Nano.

- The system shall use GStreamer for video processing.
- The system shall use OpenCV for computer vision tasks.

4. **Algorithms**
   - The system shall implement path planning algorithms for autonomous navigation.
   - The system shall implement computer vision algorithms for lane detection and following.
   - The system shall implement machine learning models for plant and weed identification.
   - The system shall implement image processing algorithms for sign detection and recognition.

3 Functional Requirements

1. **Autonomous Navigation**
   - The system shall navigate autonomously on the complete track, adhering to the right lane.
   - The system shall implement shortest path algorithms to optimize navigation.
2. **Lane Detection**
   - The system shall detect and follow solid and dashed lines on the road-track using one of the cameras.
3. **Plant Identification and Treatment**
   - The system shall identify and classify healthy sugar beets, diseased sugar beets, and weeds using the second camera and machine learning models.
   - The system shall use unique markers (signs) to assist in plant identification.
   - The system shall implement mechanisms for eliminating weeds.
   - The system shall implement mechanisms for treating diseased plants.
   - The system shall implement mechanisms for distributing fertilizer to healthy plants.
4. **Sign Recognition**
   - The system shall detect and recognize unique markers representing different plant types and conditions.
   - The system shall adjust navigation and actions based on detected signs.

4 Testing and Validation

1. **Test Environment Setup**
    - The system shall ensure the test environment size is 7.5 meters by 3.5 meters.
    - The system shall set up the road-track with solid and dashed lines.
    - The system shall place unique markers (signs) representing different plants within the test environment.
2. **Performance Metrics**
    - The system shall measure the accuracy of lane detection and following.
    - The system shall evaluate the precision and recall of plant and weed identification.
    - The system shall assess the efficiency of navigation in terms of the shortest path and adherence to the right lane.
    - The system shall evaluate the effectiveness of weed elimination, disease treatment, and fertilizer distribution.
3. **Simulation and Real-world Testing**
    - The system shall develop and test algorithms in a simulated environment before deploying on the physical vehicle.
    - The system shall conduct real-world tests to validate performance under various conditions.

5 Documentation

1. **User Manual**
    - The system shall include instructions for assembling the hardware components.
    - The system shall provide guidelines for setting up the software environment.
    - The system shall provide steps for running the autonomous navigation and plant identification systems.
2. **Technical Documentation**
    - The system shall include a detailed description of the hardware setup.
    - The system shall provide an explanation of the software architecture and algorithms used.
    - The system shall include a troubleshooting guide for common issues.

3. **Source Code and Repositories**

   - The system shall maintain a version-controlled repository (e.g., GitHub) for all source code.
   - The source code shall include comments and documentation for clarity.