**Technical Project Report**

**Title:** Implementing LiDAR and I3D CNN Algorithm Technique in Industrial Robots for Human and Object Detection in Real-Time

### **1. Introduction**

This project aims to enhance industrial robot safety and efficiency by integrating a single LiDAR sensor and an Inflated 3D Convolutional Neural Network (I3D CNN) algorithm to detect humans and objects in real-time. By creating two concentric detection zones using LiDAR data, the robot’s behavior can dynamically adjust: reducing speed when objects are nearby and stopping entirely if objects enter a critical proximity. This approach replaces traditional cage-based systems, increasing safety, flexibility, and workspace efficiency.

### **2. System Design and Specifications**

#### 2.1 Detection Zones

* **Zone 1 (Slow Zone):** Radius of 3 to 5 meters. If a human/object is detected here, the robot slows down to a safe reduced speed.
* **Zone 2 (Stop Zone):** Radius of 1 to 2 meters. If a human/object enters this zone, the robot performs an emergency stop.

#### 2.2 Hardware Specifications

| Component | Specification |
| --- | --- |
| Safety LiDAR | Hokuyo UST-10LX, 10m range, 270° FOV (effective at 6m) |
| Vision LiDAR / Depth Cam | Intel RealSense D435i |
| Compute Unit | Industrial PC + NVIDIA RTX A4000 GPU / Jetson AGX Orin |
| Safety PLC | Certified SIL2/3 Safety Controller |
| Misc. Hardware | Mounts, cables, connectors |

### **3. Software and Algorithm Implementation**

#### 3.1 Dataset Preparation

* Collect and label ~1000 short LiDAR and video segments.
* Annotate sequences with human/object presence and zone information.

#### 3.2 I3D CNN Setup

* Utilize a pretrained I3D model from TensorFlow or PyTorch.
* Fine-tune on collected dataset using temporal segments (e.g., 16-frame clips).
* Optimize with lightweight layers (e.g., separable conv or S3D).

#### 3.3 Integration Architecture

* **Sensor Fusion Module:** Sync LiDAR point cloud and depth frames.
* **Inference Engine:** Run I3D CNN on live data stream.
* **Decision Logic:**
  + If detection in Zone 1 → reduce speed.
  + If detection in Zone 2 → stop robot.

#### 3.4 Pseudocode

if detect\_object():  
 if object\_distance < stop\_zone:  
 robot.stop()  
 elif object\_distance < slow\_zone:  
 robot.reduce\_speed()  
 else:  
 robot.normal\_speed()

### **4. Step-by-Step Working of the System**

1. **Initialization**
   * LiDAR, depth camera, and compute units are powered and calibrated.
   * Robot and safety PLC systems are synchronized with the LiDAR system.
2. **Live Data Capture**
   * The LiDAR continuously scans the surroundings (up to 10m) at 40 Hz.
   * Depth camera captures frames for vision validation.
3. **Sensor Fusion**
   * Real-time synchronization of LiDAR point cloud and video frames.
   * Data is preprocessed and temporally stacked for CNN input.
4. **Object Detection with I3D CNN**
   * Stacked temporal frames are fed into the I3D CNN.
   * Output labels determine object presence and classification.
5. **Zone Check Logic**
   * The object’s location is measured against Zone 1 and Zone 2 thresholds.
   * Logic controller interprets position and triggers necessary response.
6. **Robot Behavior Control**
   * If the object is in Zone 2 → emergency stop.
   * If in Zone 1 → slow down the robot.
   * Else → normal operation.
7. **Logging and Safety Verification**
   * All events are logged for traceability.
   * Safety PLC verifies sensor inputs and overrides action if needed.
8. **Shutdown & Diagnostics**
   * Daily diagnostics are run to ensure the accuracy of LiDAR and CNN predictions.
   * System resets for the next operational cycle.

### **5. Conclusion**

By integrating a single Hokuyo UST-10LX LiDAR sensor and I3D CNN algorithms, this project enhances the adaptability and safety of industrial robots. The updated system maintains efficiency while offering greater flexibility and real-time safety performance compared to traditional caged setups.

**End of Report**