

Project ALFRED

Technical Requirements Document

Technical Requirements Document (TRD) for Building Alfred: The Humanoid Receptionist Robot

Introduction

This document outlines the technical requirements and a detailed implementation plan for building Alfred, a humanoid robot designed to greet and interact with visitors at the Innovation Lab. The project aims to enhance visitor engagement while providing an innovative and futuristic experience. The document covers 3D printing requirements, electronic components, supported movement capabilities, cost-efficient methods, and a detailed 12-week implementation plan.

Technical Requirements

3D Printing Requirements

Component	Details
3D Printer Models	Creality Ender 3, Anycubic i3 Mega, or Prusa i3 MK3
Time to Build	Approximately 200 hours of printing time, depending on the complexity and size of the parts
Filaments	PLA or ABS filaments. PLA is preferred for ease of use and lower printing temperatures
Compatible Models	Reachy and Poppy models are compatible with most FDM 3D printers. Parts will be scaled as needed

Cost of Hardware

Item	Estimated Cost (INR)
3D Printer	20,000 - 50,000
Filaments (per kg)	1,500
Total Estimated Cost	25,000 - 60,000

Electronics Components

Component	Details	Estimated Cost (INR)
Microcontroller	Raspberry Pi 4 or Arduino Mega 2560	4,000 / 1,500
Cameras	Logitech C920 or Raspberry Pi Camera Module	8,000 / 2,000
Microphones	USB Microphone or MEMS microphones	1,500 / 500
Ultrasonic Sensors	HC-SR04	100 each
Motors	MG996R or Dynamixel AX-12A (Servos), NEMA 17 (Stepper Motors)	300 / 6,000 each, 1,200 each
Power Supply	12V 10A power supply	2,000
Additional Components	Breadboards, jumper wires, resistors,	2,000

Cost of Components

Category	Estimated Cost (INR)
Microcontroller and Accessories	6,000
Sensors	12,000
Motors	25,000
Power Supply and Additional Components	4,000
Total Estimated Cost	47,000

Supported Movement Capabilities by the Humanoid

Movement	Description
Head Movements	Pan and tilt using servo motors
Arm Movements	Shoulder and elbow movements for waving and gesturing
Hand Gestures	Basic open/close actions
Tracking Movements	Utilizing cameras and sensors to follow guests
Audio-based Cues	Nodding in response to speech recognition

Cost-Efficient Ways to Build and Test the Humanoid

Method	Description
Simulation Software	Use Gazebo or V-REP for testing in a virtual environment before physical assembly
Modular Design	Develop and test individual modules (e.g., head, arm) separately to identify issues early
Reuse Components	Utilize components from previous projects or educational kits to reduce costs

12-Week Implementation Plan for Building Alfred

Phase 1: Planning and Design (Weeks 1-2)

Week		Tasks	Milestones
	1	Project kickoff meeting, define project scope and objectives, assign roles, finalize design specs	Project plan finalized, team roles defined, design specs completed
	2	Identify components, source and order materials, create CAD models, develop project timeline	Orders placed, CAD models completed, project timeline completed

Phase 2: 3D Printing and Parts Preparation (Weeks 3-4)

Week		Tasks	Milestones
	3	Set up 3D printers, begin printing parts, start post-processing	3D printer setup completed, initial parts printed and post-processing started
	4	Continue 3D printing and post-processing, conduct quality checks	All parts printed, quality checks completed

Phase 3: Electronics Integration (Weeks 5-6)

Week		Tasks	Milestones
	5	Set up microcontroller, integrate cameras and microphones, begin wiring	Microcontroller setup completed, cameras and microphones integrated, initial wiring started

	6	Connect and test motors, assemble electronic components into the physical structure, initial system integration tests	Motors connected and tested, electronic components assembled, initial integration tests completed
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Phase 4: Software Development (Weeks 7-9)

Week		Tasks	Milestones
	7	Develop initial software for basic control and movement, test basic control software, develop vision processing algorithms	Initial control software developed and tested, vision processing algorithms developed
	8	Develop speech recognition and TTS capabilities, integrate vision and speech software, test and refine vision and speech capabilities	Speech recognition and TTS software developed, vision and speech components integrated and tested
	9	Develop conversation scripts and interaction protocols, implement and test notification system, conduct integration tests	Conversation scripts and interaction protocols developed, notification system implemented and tested, integration tests completed

Phase 5: System Integration and Testing (Weeks 10-11)

Week		Tasks	Milestones
	10	Perform full system integration, conduct comprehensive testing	Full system integration completed, comprehensive testing started
	11	Finalize system adjustments, conduct user acceptance testing	System adjustments completed, UAT completed, preparation for deployment

Phase 6: Deployment and Training (Week 12)

Week	Tasks	Milestones
12	Deploy Alfred, train lab staff, monitor performance	Alfred deployed, staff training completed, performance monitoring and final adjustments made

Summary of Engineering Resources

Activity	Duration	Engineers Required
3D Printing and Parts Preparation	4 weeks	2 engineers
Electronics Integration	2 weeks	4 engineers
Software Development	3 weeks	2 software engineers
System Integration and Testing	2 weeks	4 engineers
Deployment and Training	1 week	2 engineers
Total	12 weeks	4 engineers

This revised plan ensures that the project is completed within 12 weeks by optimizing the workflow and overlapping tasks where feasible. Each phase is carefully planned to minimize delays and ensure efficient use of resources.