Multi-Purpose Robotic Arm

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**Concept of Operations**

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Concept of Operations

for

Team Bomb Squad

Team <15>

Approved by:

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# Executive Summary

The ultimate objective is to design and construct a mechanical appendage that’s controlled and operated wirelessly using a custom designed tracking system. The purpose of this multi-purpose robotic arm is for emergency situations where human senses and control is critical without having a physical person present. This robot would have six different tool attachments in order to interact with the surrounding environment while keeping the user at a safe distance. The difference between this robot and conventional robots with extensions is that this can be controlled wirelessly through simulation solely based on the user’s movements while still have the usability of numerous types of tools. This brings the user’s natural movements to the situation combined with machine capabilities so that the problem can be resolved with a human’s direct perspective. Lastly, there would be a mounted utility belt around the forearm that would be used to change the application of the hand to different kinds of projects. Depending on the situation, a utility belt would be able to revolve around the arm and attach itself to the clamp. This concept combines the mobility of the arm and the usability of machines.

# Introduction

The purpose of this project is to further extend the capabilities of the already invented mechanical hand that’s wirelessly controlled using an arm simulator. The plan of action is to mount different attachments to increase the usability of the robot. Furthermore, a rotating utility belt would be fitted directly onto the arm that will automatically fit the hand with various tools if a button is pressed. Extending the capabilities is crucial especially for extreme conditions such as defusing bombs. There may be instances where a drill or a saw may be necessary.

## Background

Currently, there are numerous versions of bomb squad vehicles on the market. However, many of the models are limited with just a clamp on an arm extension. This model seeks to upgrade and integrate technology not currently used for common bomb squad vehicles in order to enhance it’s capabilities. One of the areas that are going to be enhanced is replacing the manual controlled arm and hand extensions that are on most bomb squad vehicles with a wireless simulator controlled extension. This technology already exist thus we would simply be integrating two technologies together. However, the main area we are going to focus on is the addition of a rotating utility belt that can be directly mounted onto the arm extension. This will greatly extend the capabilities of the arm. Furthermore, we are also planning on integrating sensors using haptic feedback. This would further increase the interactiveness of the extension by allowing the user to have a sense of the robotic arm in its surroundings when the extension comes into contact with an object. Many robotic arms like this only have a clamp but with a combination of different tool attachments on the arm, the controller could have more capabilities in the field.

## Overview

The project includes the 6 subsystems listed below:

1. Utility Attachment System
   1. Tool 1: Drill (Including drill bits)
   2. Tool 2: Electric Saw/Dremel
   3. Tool 3: Wire Cutters
   4. Tool 4: Needle Camera
   5. Tool 5: Lighter
   6. Tool 6: Digital Multimeter
2. Brain (Microcontroller) System
3. Arm Tracking System
4. Physical Robotic Arm System

With sufficient time and effort, the comprehensive system that is composed by the subsystems listed above could be designed with low cost into a more friendly user interface for a bomb squad vehicle in a high stake situation. This would also improve bomb disposal efficiency. Other than the bomb squad vehicle, this concept could be manipulated to fit in many other fields, such as disaster rescue, military applications, and in the clean room fabrication industry.

## Referenced Documents and Standards

# Operating Concept

## Scope

The main task of our project is to control the arm wirelessly. The robotic arm should produce exact movements from the user’s arm realistically and smoothly.

## Operational Description and Constraints

**Description:**

The control system of the robotic arm would consist of multiple sensors on the arm to track the movement on the arm.

**Constraints:**

1. Range: The range that our control system can operate could be approximately 30 to 50 feet.
2. Power: The power (battery life) of the robot might not be enough for long time usage. The robot may have to charge every 2-3 hours.
3. Flexibility: The rotation of the arm and wrist are constrained by the movements of the servo motors which may not exactly mimic the rotation of an actual arm.
4. Cost: The materials of the arm and tools are the most expensive and there may be several extra motors and several microcontrollers needed.
5. Weight: The robotic arm will be much heavier than anticipated because of the tool attachments. Stronger motors and more power will be needed to combat this.

## System Description

1. Utility Attachment System
   1. Utility belt rack and pinion motor system
   2. Tools attachments and bits
   3. Separate power distribution for higher power applications
2. Brain (Microcontroller) System
   1. Arm motor coding
   2. Hand motor coding
   3. Glove sensor data receiver
3. Arm Tracking System
   1. Interior Sensors paired with haptic feedback
   2. Data transmitter
   3. Power and usability
4. Physical Robotic Arm System
   1. Motor use and movement
   2. Flexibility and range of motion
   3. Modifications such as extensions and sensors

## Modes of Operations

Multiple modes of operations are provided because the project is designed to be highly modularized. Different project packages can be used depending on different operation tasks. Besides the basic mode of fetching and grabbing objects, the robotic arm can be mounted with different tools for different applications that vary from construction, electrical, or mechanical work.

## Users

Anyone with experience in their field of work that requires power tools should be able to operate this system. The installation and setup wouldn’t be very difficult because the robotic arm would be in one piece thus no installation would be required on the field to conserve time. This extension can be used in a multitude of applications thus would be able to benefit a wide range of users. One of the main users for example are a bomb squad team who can use it to dispose or disable bombs or other hazardous material. Furthermore, industries may also use this for tasks such as fixing power lines. This would eliminate the risks of work related accidents for instance. Furthermore, the utility belt would be automatically controlled once a button is pressed. The buttons would be on the glove itself thus this would be extremely user friendly.

## Support

This device could come with both an instruction manual as well as a video guide featuring a person using the device. Furthermore, a schematic would be provided featuring details and the construction of the arm as well as the code which will be open source allowing for future enhancements. The utility belt attachment will also come with a manual and the buttons would determine which component in the belt is utilized. These buttons would be labeled to further enhance the user friendliness of the device.

# Scenario(s)

## Scenario 1: Bomb Squad

In the case where a bomb squad robotic vehicle is deployed on a scene, time, usability, and mobility of the robot is of the essence. By giving the bomb squad personnel a controller that is calibrated to his/her own motor movements, it brings their perspective directly onto the scene in order to defuse or dispose of the bomb.

# Analysis

## Summary of Proposed Improvements

Typical robotic arms have limited arm and hand mobility and firmness. This is due to the lack of appropriate amount of motor power to physically grip onto objects. Motor design and power draw is very important to improving these constraints. This design would incorporate different tool attachments rather than a simple hand or clamp so that the user could completely work in the scenario at hand. The tools could be switched on a rotator that would be controlled by simple buttons on the user’s actual arm. There are many applications that could use a mobile system like this in order to give the user a real sense of being in a dangerous environment while still being a safe distance away.

## Disadvantages and Limitations

Cost is the main limitation for our project. Due to this cost constraint, our robotic arm won’t be made out of the highest quality material attached. Furthermore, since this will be a first generation robotic arm with all of the different integrations, it won’t necessarily have the most efficient code although the software will be open source to allow for further future updates. Lastly, there may not be enough time and resources to build the hand extension part for the robotic arm so the first prototype may only include the tool attachments.

## Alternatives

The alternative plan is to use Microsoft Kinect to map and track human arm movements so that a 3-dimensional digital model can be created. This digital model can be used for generating the control signal for the robotic arm. The pros for this alternative plan include not having to create the glove hardware due to the fact that kinect digitizes the arm movements. Furthermore, it can be more precise in terms of arm movement. However, for the cons, It will require more sophisticated software as well which could be more pragmatic to use especially on the field. The Microsoft Kinect would be more complex to set up as well in the field.