Operation Manual

Team 15

Assembling and controlling "The Bear" portable tree harvester

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Introduction

Tree harvesting practices create great risk for human injury and damage to surroundings. For example, many trees have fallen on cables, nearby houses, and people. In addition, harvesting trees is expensive to the average consumer due to these dangers that arise. Our team is engineering a machine that can climb, de-limb, and section a tree. A worker controls this machine, at a safe distance, to avoid falling limbs. The machine's name, The Bear, comes from the way it climbs a tree like a bear. Hydraulics power The Bear, which consists of two clamps to grip the tree trunk. The top clamp acts as the bear's arms and the bottom clamp acts as the bear's legs. The Bear climbs up the tree, using these two clamps. The top clamp has a de-limbing blade to remove limbs as the device climbs. Once The Bear nears the top of the tree, it will begin to section the tree from the top as it climbs down.

Functional Analysis

Similar to most stroke harvesters, "The Bear" has two clamps on both ends to secure itself on the tree. However each clamp has a distinct design to perform the various tasks that are required for the tree harvester. The lower clamps are designed to hold up the machine. The rotating claw includes a smaller parallel trapping claw on the bottom allowing for more surface contact to the tree. This claw is designed be able to wrap around various tree diameters. The top clamp is used for both securing and de-limbing the tree. Both claws are designed with an edged arc on the top surface that will act as a shearing blade for de-limbing. The clamp mounts will hold both claws in position and guard the hydraulic cylinders from any debris that could fall on the machine. The mount can be disassembled with screws for allowing easy access to replace any malfunctioning parts that is affecting the machine's function. The top connector plate is used to join the shearing hydraulic cylinders to the top clamp mount. The hub or body is where the electronic and hydraulic control system is secured. Carefully placed holes were created to allow for hydraulic hoses to travel freely to their necessary ports. The hub is designed with space to include other control systems such as sensors and small measuring devices to maintain constant feedback of the hydraulics within the machine.

Project Specification

Mechanical

Hydraulic Cylinders:

- 1.5 in. Bore Diameter, Weight: 8 lbs, Port Size: SAE #4, Stroke: 6 in., Max Pressure: 3000 psi, Double Acting (Welded)

Figure 1: Hydraulic cylinder used for shearing and top clamp

- 2 in. Bore Diameter, Weight: 17 lbs, Port Size: NPT ⅜ in. , Stroke: 6 in. , Max Pressure: 2500 psi, Double Acting (Tie Rod)

Figure 2: Hydraulic cylinder used for bottom clamp

Hydraulic Manifold:

- Length: 5 in. , Width: 3 in., Height: 3 in., Type: 3 stations

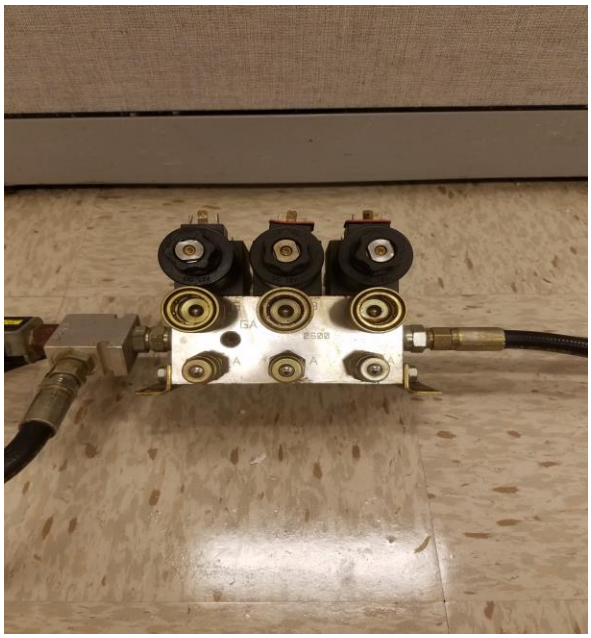

Figure 3: Side view of manifold

Solenoid valves:

- Type: 3 way 4 directions, Voltage: 12V DC, Current: 2 A

Figure 4: Solenoids

Hydraulic Motor Pump Unit:

- Power: 3.8 HP, Max RPM: 3600, Max Pressure: 4000 psi, Volume: 118 cc, Length: 20 in. , Width 10 in. , Height 24 in. , Weight: 45 lbs

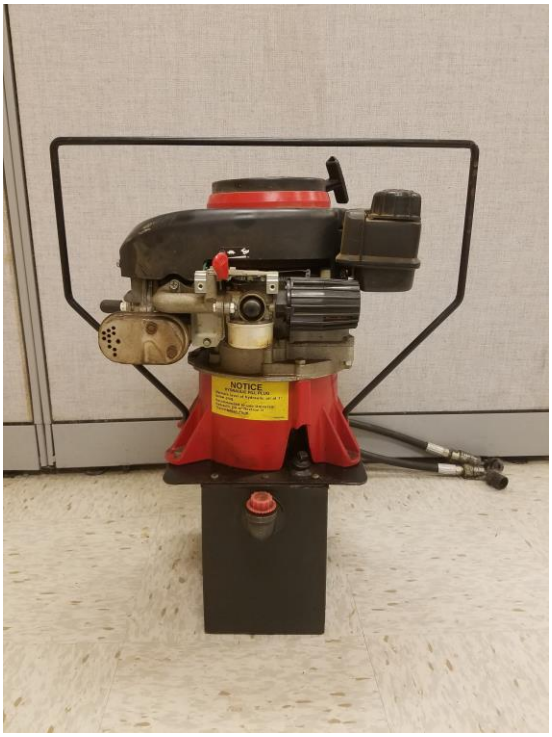

Figure 5: Reservoir, pump, and motor

“The Bear” Hub:

- Outer dimensions: Length: 20 in., Width: 20 in., Height: 20 in.

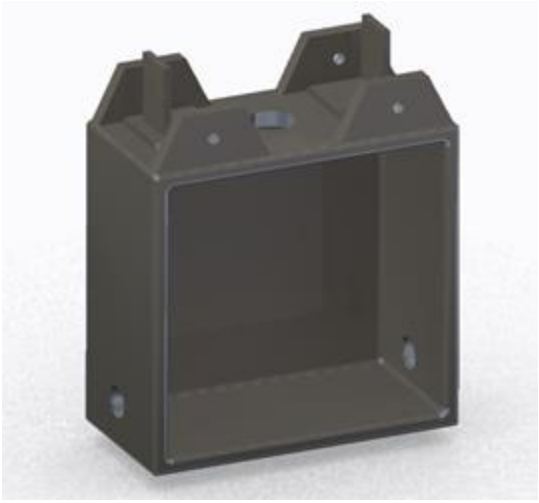

Figure 6: Design of hub

Electronics

Arduino Uno R3:

- Microcontroller: ATmega328, Operating Voltage: 5V, Input Voltage (recommended): 7-12V , Input Voltage (limits): 6-20V, Digital I/O Pins: 14 (of which 6 provide PWM output), Analog Input Pins: 6, DC Current per I/O Pin: 40 mA, DC Current for 3.3V Pin: 50 mA, Flash Memory: 32 KB (ATmega328) of which 0.5 KB used by bootloader, SRAM: 2 KB (ATmega328), EEPROM: 1 KB (ATmega328), Clock Speed: 16 MHz

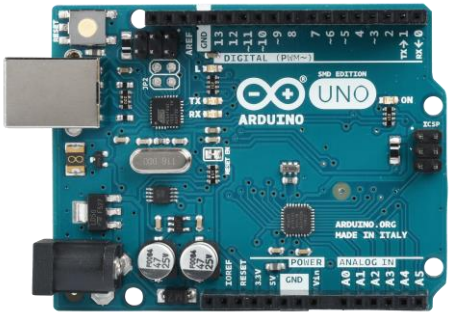

Figure 7: Arduino

Digi Xbee wireless adapter:

- Indoor/Urban range: up to 133’ (40 m), Outdoor line-of-sight range: up to 400’ (120 m), Transmit Power: 2 mW (+3 dBm), Receiver Sensitivity: -95 dBm RF, Data Rate: 250,000 bps

Figure 8: Xbee

Xbox 360 Controller:

- 2× Clickable analog sticks, 2× Analog triggers, 11× Digital buttons (wireless controller features additional button for syncing purposes), Digital D-Pad, Wireless: proprietary 2.4 GHz protocol, power: Nickel-metal hydride battery; 2 × AA, weight: 265 g

Figure 8: Xbox 360 controller

Assembly

Mechanical

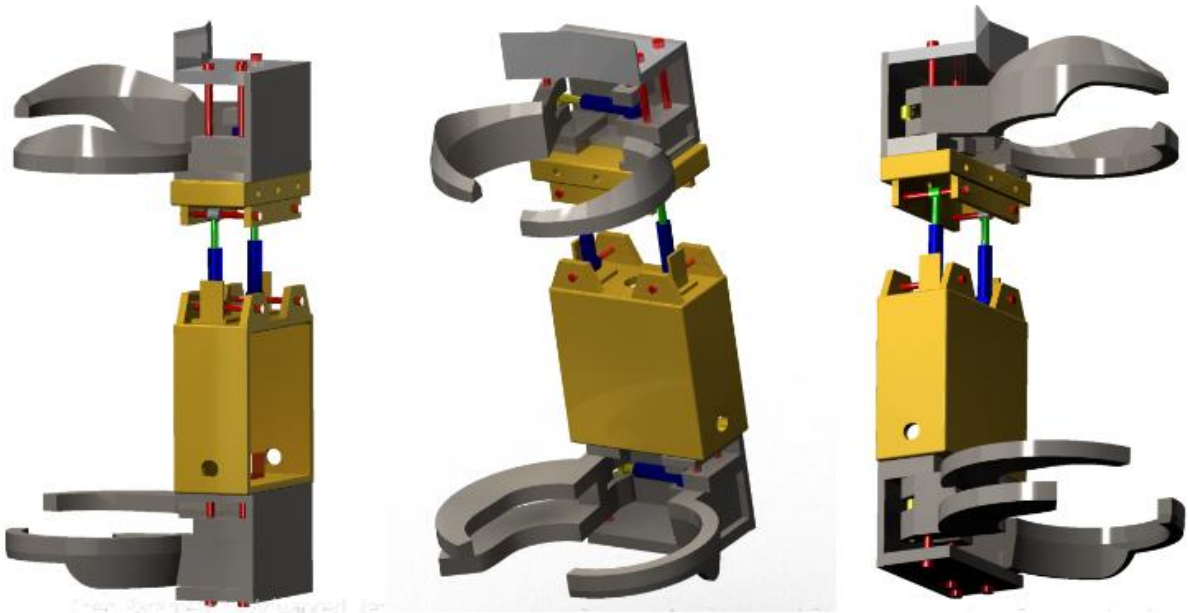

Figure 9: Design of “The Bear”

A full assembly of the ROV can be seen in Figure 9. This figure shows the body of our design without the hydraulic assembly. The top and bottom clamp will each consist of three major parts: the rigid arm, the moving arm, and the clamp mount. The two arms of the clamp will be bolted/screwed down to the bottom and top clamp frame. A hydraulic cylinder will be assembled between the two arms in the clamp mount in order for the clamps to open and close. The assembly of the top and bottom clamp can be seen in Figure 10 and Figure 11, respectively. The red claws indicate that they are rigid while the green claws indicate the moving components of the clamp. The bolts and pins are not shown in these pictures in order to clearly see the major components.

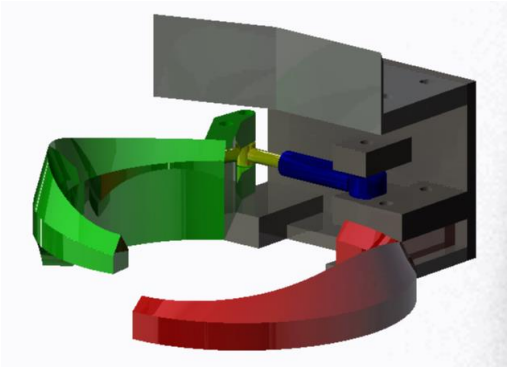

Figure 10: Top clamp

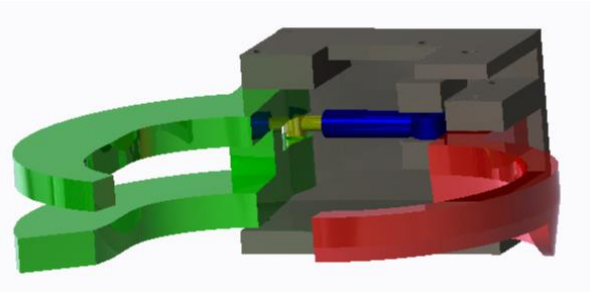

Figure 11: Bottom Clamp

The top clamp mount will be assembled to the top connector plate using screws. The bottom clamp mount will be connected in the same manner to the hub. The top frame and the hub are connected by two hydraulic cylinders, which are secured using bolts and can be seen in Figure 12.

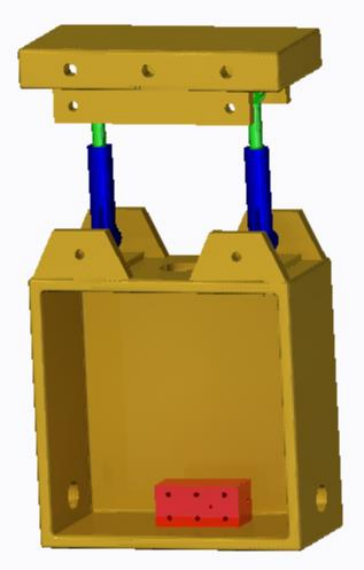

Figure 12: Frame and hub of “The Bear”

The assembly of the hydraulic system can be seen in Figure 13. The motor, pump, and reservoir will not be connected to the body of the ROV, but will have hose running to the manifold, which will be secured inside of the hub. This manifold is also seen in figure 12 above. From the manifold, 6 hydraulic hose lines total (3 in and 3 out) are running to and from the cylinders. One line to the top clamp, one to the bottom clamp, and one to the middle clamps. Only one line is needed for the middle clamps because there is a T-joint that is used to connect both cylinders to one line.

Figure 13: Assembly of hydraulic system

Electronics

The electronics are placed in an rectangular water proof box where the component will be secured so that they will not move as the ROV climbs. The box has 7 cables coming out from which 6 are to connect to the solenoid valves and 1 to the relief valve. The solenoid cables are coming out of the box in groups of two, one on top of the other and these two cables create the pair of cables that connect to each solenoid valve in the same way as they are positioned, top to top and down to down. The relief valve cable is black in order to differentiate with the others. This single cable is connected to the relief valve. The power source, a battery, is placed inside the water proof box and can be replaced if needed. The box is placed inside the hub and during operation it must be properly closed and when opened must be kept away from fluids to avoid damaging the circuits and power source.

Figure 14: Electronic controls

How to Turn On

Electronic box and Controller

1. Begin by turning the on switch inside the electric box to active all electronic systems
2. Then turn on the Xbox 360 controller by pressing the middle button. A flashing light should indicate wireless connection between the controller and the electric box.

Motor and Pump

1. Once all the electronics have been turned on. The Motor is ready for operation.
2. Prime the carburetor by pressing the rubber button below the choke. To ensure proper ignition, prime 3-4 times.
3. Open the throttle to the rabbit setting
4. Pull on the starter chord. You may have to repeat several times before motor turns over.

How to Use

1. After all systems have been turned on and prepped, the ROV is ready to begin operating.
2. In order to secure the ROV on the tree, make sure the Clamps are at their max opening position. Do this by pressing the “Open Clamps” button on the user controller.
3. Then place the ROV on to the tree and ensure there is no debris that can hinder clamping or climbing operations.
4. Press the “Close Clamps” button to secure the clamps around the tree. Once clamps are set, the ROV is ready to climb.
5. To begin the climbing cycle, push the joystick up. The “UP” state will be initiated and the ROV will perform a full climb cycle. The climb cycle includes extending both shearing hydraulic cylinders, securing to the tree using the top clamp, releasing pressure on the bottom clamp and retracting the shearing cylinders to original position, and re-securing the bottom clamps on to the tree.
6. To continue climbing, keep the joystick pressed. The ROV will read any signal from the user controller once a full cycle has been performed.
7. To avoid severe malfunction and potential damage to ROV, if a unfamiliar event is occurring, pressing the “emergency shut down” button will deactivate any electronic operations from further potentially damaging the ROV.

8. To stop climbing simply release the joystick back to its original position.
9. To activate the “Down” state, press down on the joystick and the ROV will initiate the down cycle to begin descent.
10. Once the ROV has reached the base of the Tree, The “Open Clamps” button can be used and the ROV is ready to be moved out of the tree trunk.
11. In order to shut down the ROV, The motor must turned off by closing the throttle and then turning of the electric box. Note: before shutting down the ROV, one can use the “Close Clamps” button to reduce space needed for storage.

How to Clean Up

1. Once the ROV is off the tree, the electronic system should be turned off, disconnected, and stored properly
2. Next, the hydraulic hose lines should be carefully disconnected from the cylinders and manifold. And then drained.
3. Finally, the body of the ROV is ready to be stored in its container.

How to Store

1. The electronics are stored separately in its own case. These are kept away from the hydraulics to make sure they stay clean and don't get oil on them.
2. The hydraulic hoses will be hung with a bucket underneath so they will be able to continually drain and will allow for an easy cleanup.
3. The ROV will be placed in its own storage carrier to keep it safe from damage. This carrier is also on wheels in order for easy transportation.