KBBQ for KBBeginners

Final Presentation

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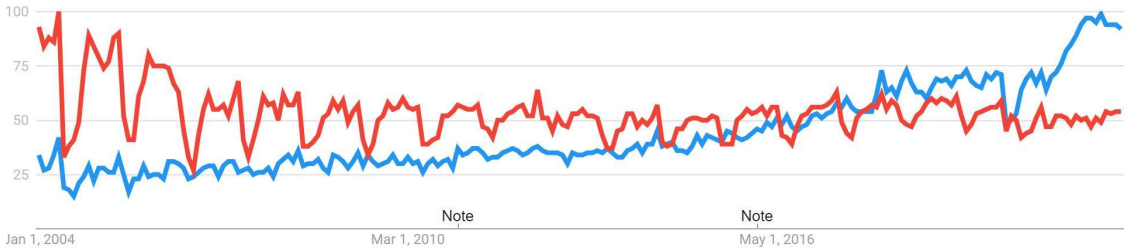
Application Area and Use Case

- Korean food is growing in popularity
- KBBQ is a “do it yourself” type of food, but may be intimidating to newcomers
- Robotic Arm must be able to reach dishes and all areas of grill. (Grill is 13.5 cm by 13.5 cm)
- Able to function for at least 20 min., at most 45 min.
- Should be cooked “just right” 70% of the time
    - No undercooking, no black burnt meat, but a good brown color
    - Determine by time (each side of meat should be cooked for 3- 5 minutes)
- CV algorithm should be able to process twice per second.



Solution Approach

- Cooked and raw meat placed on either side of the robotic arm
- If there is food on the raw meat plate and there is empty space on the grill, then it will pick up the meat and pass it in front of the side camera to get a cross-section view
- Computer vision will determine how thick the meat is and will use that information along with the temperature of the grill to determine how long that cut of meat should stay on the grill
- We will prioritize flipping and removing meat that is currently on the grill over putting on new meat to assure quality
- Once our algorithm decides that a certain piece of meat is finished cooking, the robot arm will then place it on a plate on the plate designated for cooked meats

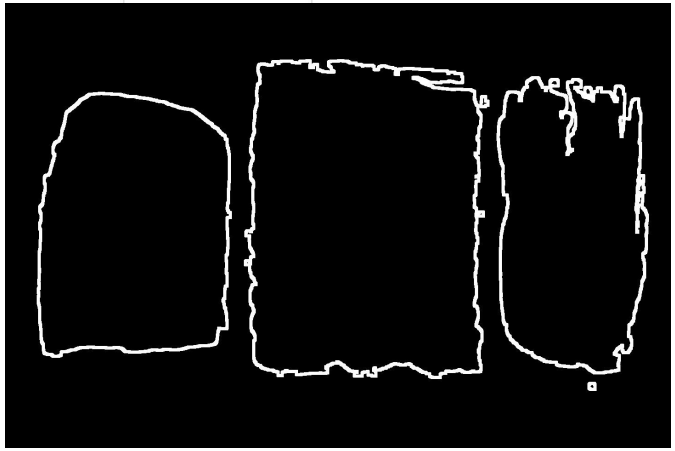
Public Demo Plan

- Bring portable DC Power supply, capable of outputting 12V and 20 A
  - Bring fully charged lead acid battery (12V, 7AH) as back-up
- Set up gas-powered grill to cook at least two pieces of meat (up to 4) on a grill at the same time
  - If gas-powered stove not allowed, will use beef jerky as substitute
  - Meat (or beef jerky) will be placed on left plate one at a time, and at random intervals
  - If gas-powered grill is allowed, proper fire-safety equipment must be near
- Two Webcams will be positioned to side of left plate and above entire grill
- Jetson AGX Xavier will be used to control CV, UI, Robotic Arm, and software controller

CV Results

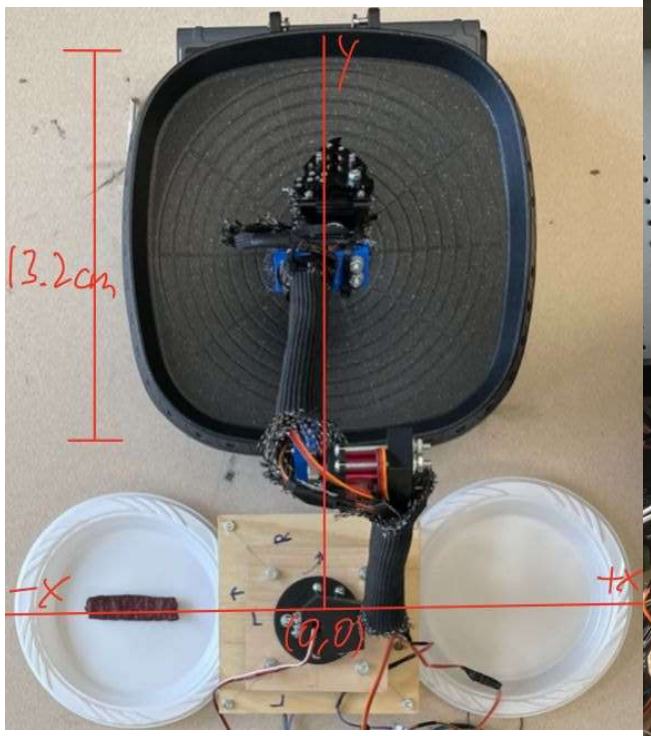
Recognition time: .05 seconds on YOLOv5, .005 seconds to determine edges. 77% Accuracy

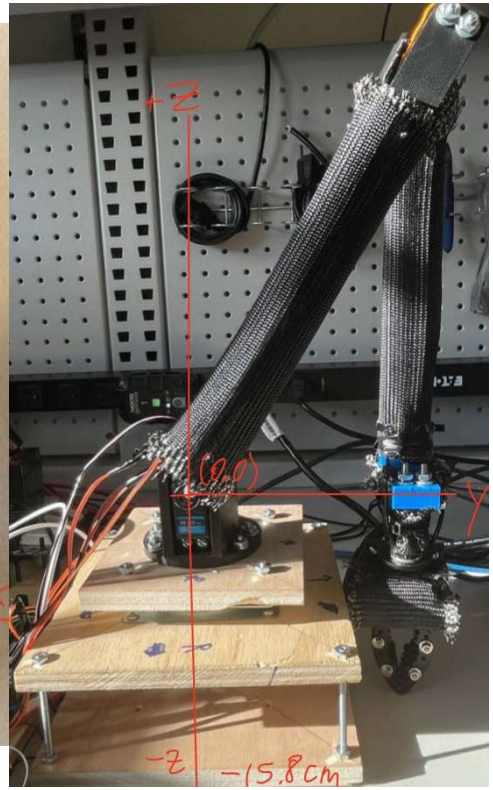
			Actual			
		Slab	Blob	Round	None	Pred Total
	Slab	13		2		15
Predicted	Blob	2	6			8
	Round	2	1	9		12
	Miss	1		1	2	4
	Total Actuals	18	7	12	2	



Robotic Arm Environment Setup

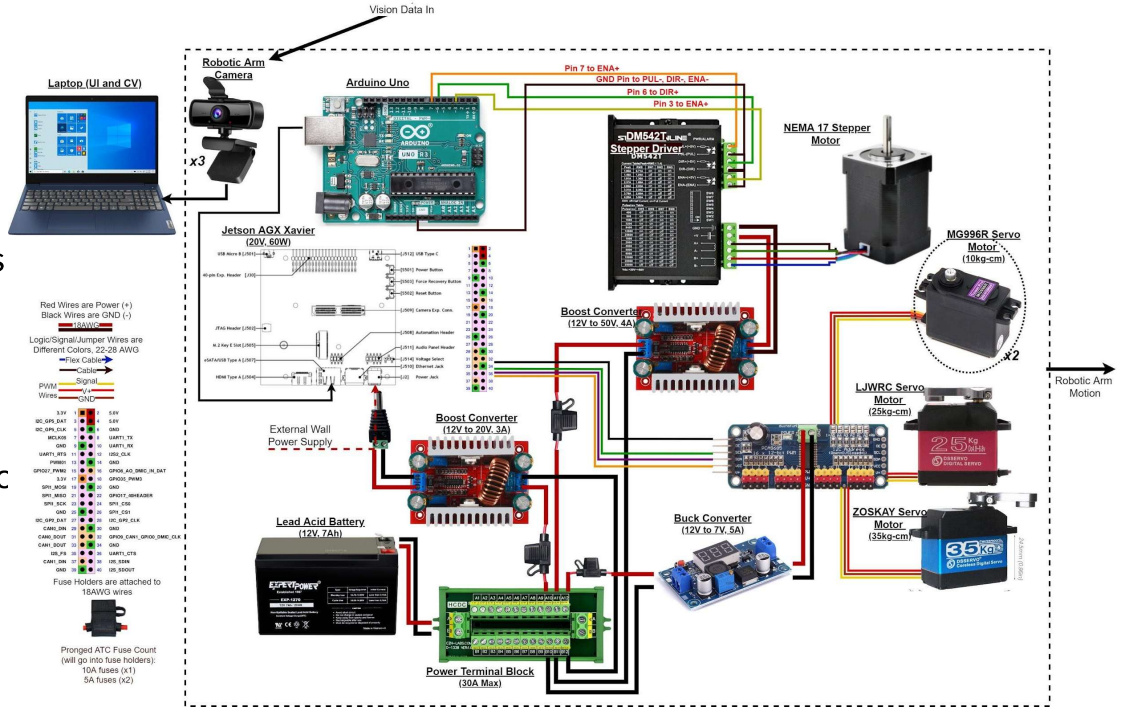
- Measured dimensions of setup and robot
- Two coordinate planes (xy and yz)
- Meat pieces max dimensions: 2 in by 5 in
- Grill height is 13.5 cm
- In xy plane (horizontal, parallel to floor), origin is the center of stepper motor (Joint0)
- In yz plane (vertical, parallel to wall), origin is center of first servo motor (Joint1)
- Plates (d=9in) are at 0 and 180 degrees (directly left and right) of base of robotic arm





Robotic Arm Implementation

- Jetson AGX Xavier GPIO pins used for I2C to control 4 servo motors in Python
- Python code uses PySerial to send desired Stepper Motor Angle to Arduino Uno, which is connected to AGX
- Inverse Kinematics of robotic arm can be simplified into a RR arm problem
- Set start (x,y,z) and end (x,y,z) for each action to calculate appropriate angles using IK: (1)Handle Raw Meat, (2)Flip meat, (3)Handle Done Meat
- Control each joint (motor) separately to avoid brown out. Claw/wrist joint are usually moved last.



- Each meat has a cooking timer that is compared to the calculated done cook time and flip time to initiate robot arm motions

UI

- UI designed to allow users to have a more interactive role in this process
- Displays information about the next piece of meat to be put on the grill
- Also allows users to get a better view of their food so they can learn how it should look when it is cooking

Testing

Current Tests

- Grill is unheated, beef jerky is used
- Testing on image data online
- Robot arm movements tested on actual setup on demo-day, with the proper dimensions
- Most robotic arm movements accuracy can be increased with tuning (and has been)

Future Tests

- Use of real fire and heated grill
  - Test done in dorm, unlikely on campus
- Actual raw meats cut to size
- Proper (real) cook time of meats can be changed with tuning
- Test queue system, with up to 4 meats on grill

Testing Metrics, Verification, and Validation

Feature	Testing Method	Output	Accuracy	Results
Meat type recognition	Placing plates of food in front of camera	Algorithm item guess	Under 5 seconds 80%+ Accuracy	.05 Seconds 76% Accuracy
Thickness Recognition	Holding cuts of meat in front of camera	Thickness estimate	±1/16 in	±1/10 in
Robotic Arm Movement Error	See if Robotic arm can touch a predetermined point	Amount of Movement Error in kinematic software	±1/16 in	±1/4 in
Cooking Time Algorithm	Manually see if the amount of time calculated properly cooks given meat	Cooking time estimate	Meat fully cooked, but not burnt Internal temp of 145F pork, 170f beef min	TBD

Testing Metrics, Verification, and Validation, Pt 2

Feature	Testing Method	Output	Accuracy	Results
Servo Motor Speed	Stopwatch, program robot joint to move from 0 to 180	Time/180	0.0022 sec/degree	Time ~1-1.5 sec 0.0056-0.0083 sec/degree
Stepper Motor Speed	Stopwatch, program robot joint to move from 0 to 180	Time/180	Result varies depending on amount of current/pulse	Time ~2 sec 0.011 sec/degree
Robot Motion Speed	Timer for 3 actions - handling raw meats, flip meats, and done meats	Time, from start to end, of an action to be completed	Less than 30 sec. each	Most actions take 20 sec to complete
Battery Power Test	Continue to give robot actions until batterty starts browning out, and robot fails an action due to lack of power	Time (mins.)	Estimate of ~30 min.	TBD

Project Management

KBBQ 4 KBBeginers

Team B5

SIMPLE GANTT CHART by Vertex42.com
https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: Mon, 2/14/2022

Display Week: 5

TASK	ASSIGNED TO	PROGRESS	START	END
Task 5	Create Subsystems Integration Plan	100%	2/25/22	3/2/22
Task 6	Design Review Presentation	100%	2/15/22	2/20/22
Task 7	Design Review Report	100%	2/15/22	3/2/22
Phase 2 Development				
Task 1	Develop CV Algorithm	100%	3/14/22	4/10/22
Task 2	Slack Time (Spring Break - Design, Develop, etc)	100%	3/2/22	3/13/22
Task 3	Develop Software Controller/UI	100%	3/14/22	4/3/22
Task 4	3D Print/Assemble Robotic Arm	100%	3/14/22	3/21/22
Task 5	Program Robotic Arm	100%	3/21/22	4/10/22
Phase 3 Integration and System Testing				
Task 1	Integrate Software Controller and CV Algorithm	90%	4/8/22	4/26/22
Task 2	Integrate Software Controller and Robotic Arm	80%	4/11/22	4/26/22
Task 3	Slack Time (Integrate, Develop, etc.)	100%	4/6/22	4/10/22
Task 4	Integrate All Subsystems	90%	4/16/22	4/26/22
Task 5	Testing CV on Actual Grill and Meats	50%	4/21/22	5/2/22
Task 6	Test Robotic Arm on Actual Grill and Meats	50%	4/21/22	5/2/22
Task 7	Complete Final Presentation	100%	4/21/22	5/7/22
Task 8	Complete Video/Poster	10%	5/2/22	5/4/22
Task 9	Complete Final Document	20%	5/2/22	5/7/22