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Modular Conveyor Belt System with Robotic Sorting

Dr. Reg Pecen, Sam Houston State University

Dr. Reg Pecen is currently a Quanta Endowed Professor of the Department of Engineering Technology at Sam Houston State University in Huntsville, Texas. Dr. Pecen was formerly a professor and program chairs of Electrical Engineering Technology and Graduate (MS and Doctoral) Programs in the Department of Technology at the University of Northern Iowa (UNI). Dr. Pecen served as 2nd President and Professor at North American University in Houston, TX from July 2012 through December 2016. He also served as a Chair of Energy Conservation and Conversion Division at American Society of Engineering Education (ASEE). Dr. Pecen holds a B.S in EE and an M.S. in Controls and Computer Engineering from the Istanbul Technical University, an M.S. in EE from the University of Colorado at Boulder, and a Ph.D. in Electrical Engineering from the University of Wyoming (UW, 1997). He served as a graduate assistant and faculty at UW, and South Dakota State University. He served on UNI Energy and Environment Council, College Diversity Committee, University Diversity Advisory Board, and Graduate College Diversity Task Force Committees. His research interests, grants, and more than 50 publications are in the areas of AC/DC Power System Interactions, distributed energy systems, power quality, and grid-connected renewable energy applications including solar and wind power systems. He is a senior member of IEEE, member of ASEE, Tau Beta Pi National Engineering Honor Society, and ATMAE. Dr. Pecen was recognized as an Honored Teacher/Researcher in ”Who's Who among America's Teachers” in 2004-2009. Dr. Pecen is a recipient of 2010 Diversity Matters Award at the University of Northern Iowa for his efforts on promoting diversity and international education at UNI. He is also a recipient of 2011 UNI C.A.R.E Sustainability Award for the recognition of applied research and development of renewable energy applications at UNI and Iowa in general. Dr. Pecen established solar electric boat R & D center at UNI where dozens of students were given opportunities to design solar powered boats. UNI solar electric boat team with Dr. Pecen's supervision won two times a third place overall in World Championship on solar electric boating, an international competition promoting clean transportation technologies in US waters. He was recognized as an Advisor of the Year Award nominee among 8 other UNI faculty members in 2010-2011 academic year Leadership Award Ceremony. Dr. Pecen received a Milestone Award for outstanding mentoring of graduate students at UNI, and recognition from UNI Graduate College for acknowledging the milestone that has been achieved in successfully chairing ten or more graduate student culminating projects, theses, or dissertations, in 2011 and 2005.

He was also nominated for 2004 UNI Book and Supply Outstanding Teaching Award, March 2004, and nominated for 2006, and 2007 Russ Nielson Service Awards, UNI. Dr. Pecen is an Engineering Technology Editor of American Journal of Undergraduate Research (AJUR). He has been serving as a reviewer on the IEEE Transactions on Electronics Packaging Manufacturing since 2001. Dr. Pecen has served on ASEE Engineering Technology Division (ETD) in Annual ASEE Conferences as a reviewer, session moderator, and co-moderator since 2002. He served as a Chair-Elect on ASEE ECC Division in 2011. He also served as a program chair on ASEE ECCD in 2010. He is also serving on advisory boards of International Sustainable World Project Olympiad (isweep.org) and International Hydrogen Energy Congress. Dr. Pecen received a certificate of appreciation from IEEE Power Electronics Society in recognition of valuable contributions to the Solar Splash as 2011 and 2012 Event Coordinator. Dr. Pecen was formerly a board member of Iowa Alliance for Wind Innovation and Novel Development (www.iawind.org/board.php) and also represented UNI at Iowa Wind Energy Association (IWEA). Dr. Pecen taught Building Operator Certificate (BOC) classes for the Midwest Energy Efficiency Alliance (MEEA) since 2007 at Iowa, Kansas, Michigan, Illinois, Minnesota, and Missouri as well as the SPEER in Texas and Oklahoma to promote energy efficiency in industrial and commercial environments.

Dr. Pecen was recognized by State of Iowa Senate on June 22, 2012 for his excellent service and contribution to state of Iowa for development of clean and renewable energy and promoting diversity and international education since 1998.

Dr. Ulan Dakeev, Sam Houston State University

Dr. Ulan Dakeev is an Assistant Professor in the Engineering Technology Department at Sam Houston State University. His areas of research include Virtual & Augmented Reality, renewable energy (wind energy), quality in higher education, motivation, and engagement of students.

Dr. Faruk Yildiz, Sam Houston State University

Faruk Yildiz is currently an Associate Professor of Engineering Technology at Sam Houston State University. His primary teaching areas are in Electronics, Computer Aided Design (CAD), and Alternative Energy Systems. Research interests include: low power energy harvesting systems, renewable energy technologies and education.

Modular Conveyor Belt System with Robotic Sorting

Abstract

This paper presents a senior design project titled modular conveyor belt system with robotic sorting that was completed in a B.S. Engineering Technology program. The main objective of the project is to design and implement a modular conveyor belt system with a sorting robotic arm that can simulate several different industrial settings for improving student understanding of real-life manufacturing environments. The second objective is to maximize the system efficiency by minimizing both the sorting time and the power consumption. Senior design students working on this project researched the effects of a modular link belt with chain and gear conveyor system and reported its benefits over the prefabricated belts. Students also explored the functionality of a sorting robotic arm that worked in tandem with targeted conveyor belt system.

This project is expected to enhance applied research efforts to reduce the overall operation and handling costs of an autonomous material transportation systems. Students initially planned to design a fully autonomous conveyor belt system that would be flexible enough to be implemented in any industry regardless of the materials being handled, however due to the complexity of the system and limited semester course hours, a prototype conveyor belt with a limited robotic sorting system was built using all 3D-designed and printed materials in the engineering technology laboratories.

Although senior students have already completed machine language, network theory and computer architecture courses, the actual programming of a functional prototype conveyor belt and robotic arm also included challenges that are reported in the paper. The conveyor system is encased in a 3D-printed filament frame having a dimension of 15x5x5 inches with smoothed curved edges in both the front and the rear sections. Since all the system parts were planned to be printed in 3D printers, students have had the liberty of using custom shape or design as no manual labor was required. The total printing time for all the parts including the links used for the belt took approximately more than 100 hours since all individual links were printed separately. Easy access to multiple 3D printers in the department helped students to expedite their material production needs. The main gears were printed using a slower and more condensed printing mode as they would be constantly moving.

3D-design sketches, functional block diagrams, project Gantt chart, actual belt and robotic arm system pictures, and bill of materials are provided. The finished product is now being used as demonstration purposes in control systems technology classes that provide a better understanding of conveyor belts, a significant part of the manufacturing industries.

Problem Definition

One of the most predominant design problems across belt, drives are the effects of load-changing in time, the effects of said load change across the conveyor belt, and the requirement of purchasing belts that are prefabricated for a specific length and purpose [1]. The same conveyor belt that has been used for a certain product or materials could later be reconfigured for a different material or for a different system since the modularity will make the belt universal. These continuous handling machines may handle plenty of material pieces that go through the manufacturing processes. Autonomous material driving belts have been used for many years in the industry, yet it has never been fully optimized. Several problems arise from the conventional design of conveyors, and a myriad of different methods can be used depending on the materials being transported.

Brief History of Conveyor Belt Systems

A conveyor belt is in simple terms the carrying medium of a conveyor belt system that generally consists of two or more pulleys with an endless gear system attached to the carrying medium. One set of pulleys is located in the front of the conveyor belt system while the other set of pulleys is usually placed at the end of a conveyor belt system. These pulleys are often driven only for the front gear system or both pulleys. Conveyor belts have been used as early as the 19th century. In 1892, Thomas Robins began exploring the functionality of a belt system used to carry coal, ores, and other products [2]. In 1901, a Swedish engineering company developed the first steel conveyor belt system, around this time most coal mines were already utilizing the early conveyor belt systems as it demonstrated a massive increase in productivity and time efficiency in that specific industry. Richard Sutcliffe, an Irish-conceived mining engineer developed the World's first underground conveyor belt and mining equipment in 1905 [2]. The introduction of synthetic conveyor belts during World War II has become a turning point in the industry and synthetic polymers and fabrics began to be used in industrial conveyor belt systems. In 1947, the American Standards Association (ASA) developed industry standards and regulations in conveyor safety [2].

Introduction

The objective of this project is to design and implement a modular conveyor belt system with sorting robotic arms that can be used in several different industrial settings. We hope to minimize sorting time and power to maximize the productivity of the system. Furthermore, streamlining the process is not the only outcome that our project can provide; it can also reduce the human interaction in said machines, reducing maintenance visits, and more importantly reducing overall operations cost. We plan to research the effects of a modular link belt with a chain and gear conveyor systems and the benefits it provides over prefabricated belts.

Additionally, we will explore the functionality of a sorting robotic arm that will work in tandem with our conveyor belt system. This study may provide a useful applied research material that may reduce the overall operation and handling costs of an autonomous material transportation system. Although the original objective of this project was to design and building a fully autonomous conveyor belt system that can be flexible enough to be implemented in any industry regardless of the materials being handled.

There are plenty of research papers published in robotic sorting applications to enhance the overall precision, reliability, and efficiency of industrial and manufacturing systems. Stommel and Xu developed a soft robotic sorting table using the application of machine learning techniques for the purpose of enhanced control of a soft, peristaltic, and XY-sorting table. They actuated the table by an array of integrated ail-filled chambers that provided to chambers to be pneumatically inflated that moving objects on the table [3].

Tsai and Lee worked on conveyor tracking control of a conveyor belt and developed multiple design examples for educational purposes. Their work contributed to reducing overall manufacturing time and improved production efficiency by increasing productivity [4]. Guelpa et al. reported their similar design work of a novel modular conveyor to handle planar fragile objects at higher speed without contact. Each conveyor element in the shape of a square block able to generate titled air jets lifting and pushing the produced object in a single direction. Their work on the motion of the objects pushed by directed air-jets was the unique in terms of optimized conveyor belt operations [5].

On the other hand, several engineering, and technology-oriented educational papers were presented at ASEE annual conferences in the fields of industrial control systems applied to robotics-based automated conveyor belts. The field of automation and controls continues to provide attractive and promising employment opportunities for many graduates. Chitikeshi et al. developed a well-defined robotics technology program from community colleges and four-year engineering technology programs [6].

Kwon et al. developed an "E-manufacturing system" that is defined as a system methodology enabling the conveyor belts and overall manufacturing operations to successfully integrate with the functional objectives using the Internet. Their Internet-based quality control scheme is called "E-Quality Manufacturing" enabling distance and remote students to reach their hands-on manufacturing laboratory effectively [7]. As part of a senior design project sponsored by industry, Padir and his students designed and implemented a unique portable robotic work cell integrating a robot manipulator with vision and conveyor system [8]. The system later provided a flexible platform for automation and robotics training purposes.

Learning Objectives

The main objective of the project is to design and implement a modular conveyor belt system with a sorting robotic arm that can simulate several different industrial settings for improving student understanding of real-life manufacturing environments. The second objective is to maximize the system efficiency by minimizing both the sorting time and the power consumption. Students should be able to introduce, identify and formulate a modern industrial research problem, and develop a solution to it through a teamwork using all available resources. Students are also required to use the techniques, skills, and modern engineering technology tools necessary for practice. Finally, students are expected to present their cost-effective modular conveyor belt system with a sorting robotic arm project implementation professionally to the academia and industry as it is appropriate.

Design and Implementation of Proposed Modular Conveyor Belt System

The proposed conveyor belt prototype is heavily constrained to maintain the cost within the limited budget provided to students. For an industrial equivalent of a real system, an ideal motor for a similar project would be a 3-phase induction motor to provide a high starting torque, good speed regulation, and reasonable overload capacity.

The proposed conveyor belt system is a chain and gear conveyor belt as seen in Figure 1. The main premise of the actual "belt" implemented is a set of 3D-printed links, that can be modularly added or removed to achieve the desired length. Mass-produced links are very cost-effective in that the size is not limited to a specific length. If the length needs to be increased, adding a few links will make the belt longer, and can take links off to make it shorter. All of these design aspects can be achieved with the same “belt” without having to purchase a completely new belt for different applications.

The modular conveyor belt system is encased in a 3D-printed filament frame approximately in the dimension of 15x5x5 inches with smoothed curved edges in the front and in the rear as seen in Figure 2. Considering the students are 3D-printing all the components, they have the liberty of using whatever shape or design as no manual labor is needed. We estimate that the total time needed to print all the parts including the links used for the belt will approximately 100+ hours of printing since students are printing individual links. Since the Department of Engineering Technology provides an easy access to multiple 3D-printers to use, longer hours can be handled without major problems other than extended processing times. If the students can print the components while all machines in parallel, it will considerably reduce the time spent in production. The frame walls and supports are printed in fast mode, as we do not have any sensitive parts in the mainframe.

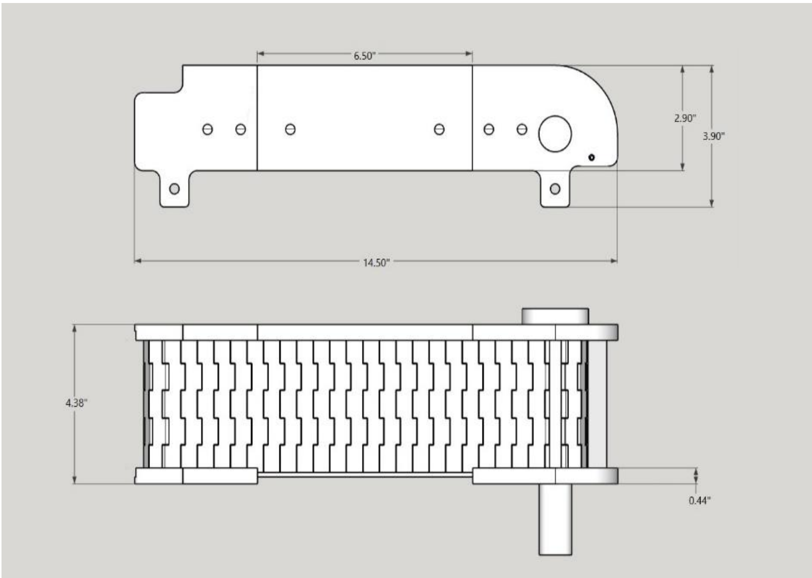

Figure 1. Proposed Modular Conveyor Belt System

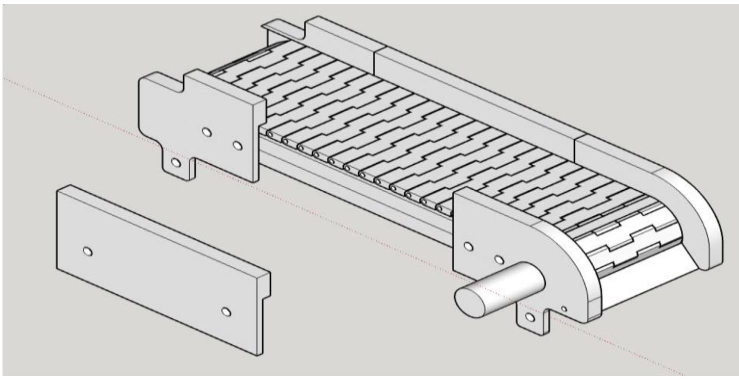

Figure 2. Isometric view of the proposed modular conveyor belt system

Functional Block Diagram of Proposed Modular Conveyor Belt System

The proposed modular conveyor belt system starts up with both robotic arms actively looking for a specific universal product code (UPC) as shown in Figure 3 of the functional block diagram. Once a barcode has been found, the reader will look within the Arduino microcontroller's code to find the predetermined location in which the box will be placed. After searching for the right information, there is still a possibility that the machine may not be able to find where the box is supposed to move resulting in a situation that the machine will go into an error state. During this state, the system will operate under a predetermined task for this specific situation while the box will be placed outside of the conveyor system and storage. If the system fails to detect any inputs (e.g. boxes or UPC) within a specific time, the system will proceed to shut down and conclude that there is no more box to sort.

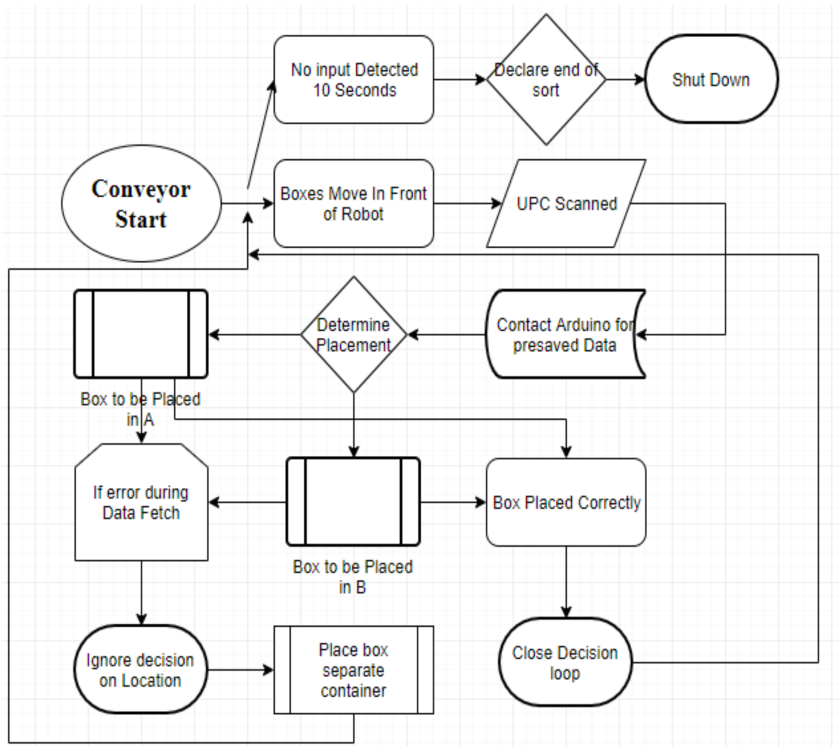

Figure 3. Functional Block Diagram of the proposed Modular Conveyor Belt System

The main gears of the modular conveyor let system are printed using a slower and more condensed printing mode as they will be constantly moving. The main shaft holder for the servo motor are also printed using thick infill of 3D-filament. The main components of the frame are shown in isometric view in Figure 4a in which both pillow blocks are included to support the rotating shaft of the main servo motor running the system. There is also one sprocket included to attach to the links providing the rotating force necessary to drive the links forward. Figure 4b depicts isometric view of the robotic arm built by all 3D-printed material.

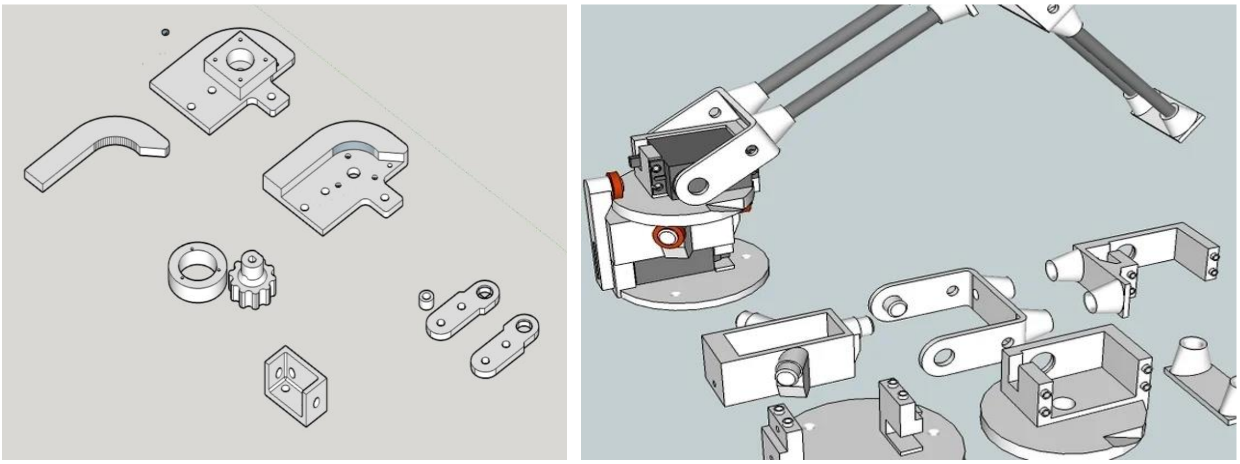

Figure 4. Isometric view of miscellaneous parts (a) and Robotic arm (b).

Students in the senior design classes are required to prepare, report, and follow detailed Gantt Charts for their project implementations. The Gantt Chart of the project is shown in Figure 5 starting with project proposal prepared earlier in the semester.

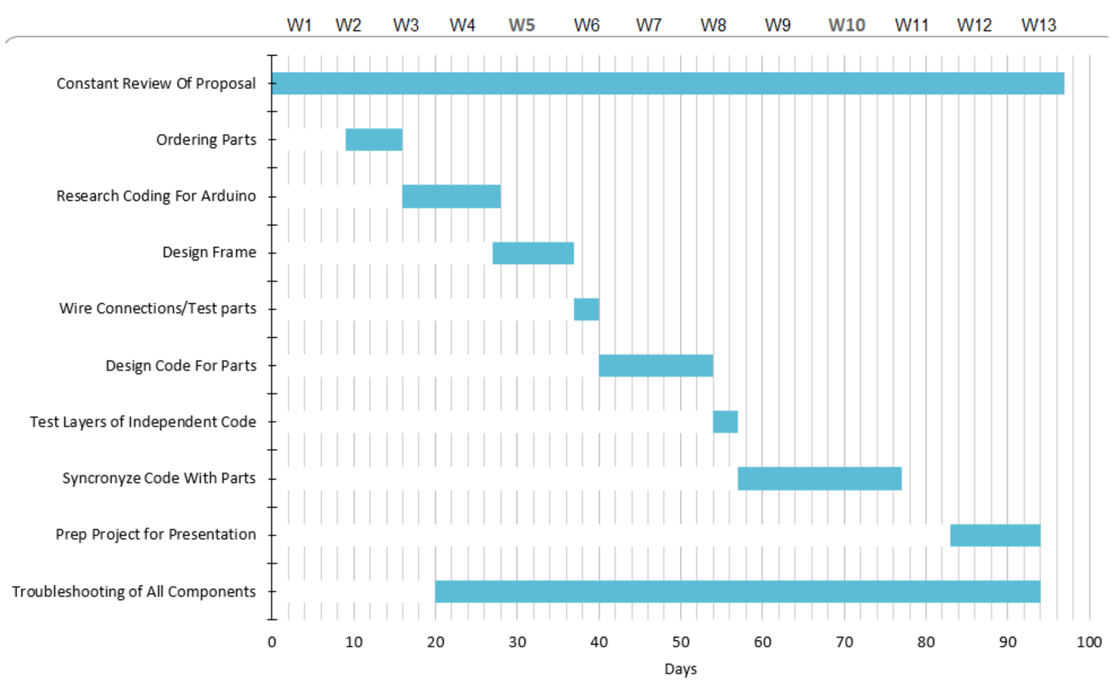

Figure 5. Gantt Chart for the completion of the proposed system

Robotic Arms

The proposed system originally consisted of two independent robotic arms which work in tandem with each other. Each robotic arm is intended to work with three different servo motors to operate at a higher precision of movement [9]. When the system is initiated, each servo motor is dedicated to operating on its own axis, the bottom one will focus on the x-axis, the middle will be y-axis, and the end will focus on the z-axis. Since students have already taken a Microcontroller class where they used an Arduino microcontroller, it will be the main piece of hardware to autonomously operate both arms [10]. An Arduino is a programmable hardware component that can convert both digital and analog inputs into instructions. It is highly versatile and can work with a plethora of inputs, the way the Arduino communicates to these inputs is through coding that closely resembles C++ language as listed on Appendix section of this paper. The scanner will detect the box and communicate with the Arduino which will then send the information back to the robotic arms with the decision to move the box to locations A, B, or to be allocated separately as an error situation. If the scanner does not detect an input, the robotic arms will determine that there is no more boxes to sort and begin to shut down [11-12].

Coding Challenge

The coding job begins with an initialization of all the electrical motors and RGB sensor. Originally there were 4 motors that oversaw movement for the robotic arm but was then switched to three following difficulties with the arm not being able to move unless each motor was moved slowly. This caused some difficulties with operation time since there would be a coding command caused the motor to move every step back and forth until it got to its correct location. An example of this would be writing Servo2.write(75); and Servo3.write(80); for the robotic arms to slowly move without breaking the plastics that held them in place. This is because of the set up where Arduino cannot run lines of code simultaneously, it needs to process each line and then executes.

The consequences cause the arm itself to be very tense and rigid since the arm locks the last motion that it was already set. After disconnecting one of the motors, the system allowed for the arm to move more fluidly that the y-axis was no longer focused on following two motors but instead focused on the movement of one motor only. After all the components were initialized the Arduino checks to find the RGB sensor and begins to record values and transfers into the if statements after confirming which statement is correct. After this step, the Arduino executes the set range of operations and system properly sorts the packages. A detailed coding is provided on Appendix A for the purpose of helping other students and faculty working in the similar fields.

Challenges and Necessary Change of Orders during the project Implementation

In this project, students expected to design and implement a fully incorporated conveyor belt system with two robotic arms sorting to demonstrate the benefits of opting for a modular design with a chain/gear system as seen in Figures 6-7. Due to the limited budget and deadline of completing all the project work in one-semester the following change orders and design modifications were implemented during the second half of the semester, therefore the senior project was completed right before the final week.

1. Instead of a metal frame and metal belts, a 3D-printed modular design was implemented.
2. Instead of two robotic arms as both thought to be redundant and time consuming, only one is designed, produced to place objects in two different bins. Figure 6 shows the original idea of two robotic arms while Figure 7 and 8 depict the actual modular conveyor belt system with one robotic arm.
3. Instead of tying every single link of the belt individually, students decided to interweave the links with a single piece of fishing line as a simplified and perfectly working solution.
4. The project dimension was elevated by two inches to harness the belt's weight for tension to the gears.
5. The modular conveyor belt system was shortened about 20% in length to minimize the filament use as well as finish the project timely.
6. Pillow blocks use were scrapped due to increased possibility of design and production errors. They were replaced by custom designed ball bearing holder on the opposite end of the motor shaft for the necessary support.

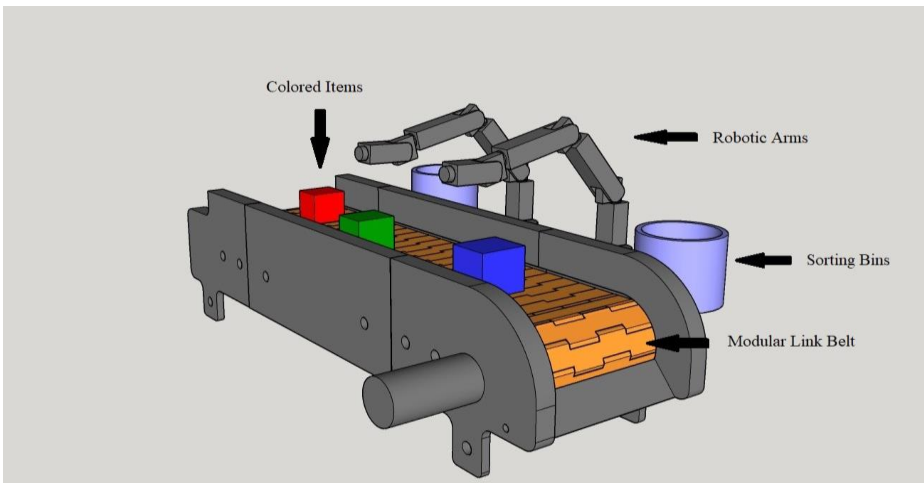

Figure 6. Final Layout of Proposed System

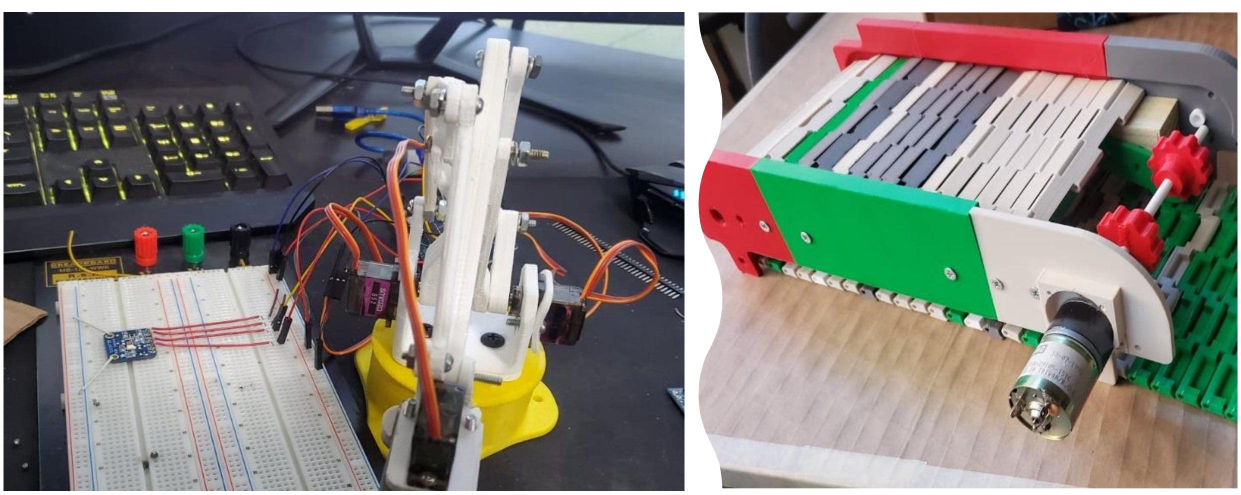

Figure 7. Actual modular conveyor belt system manufactured

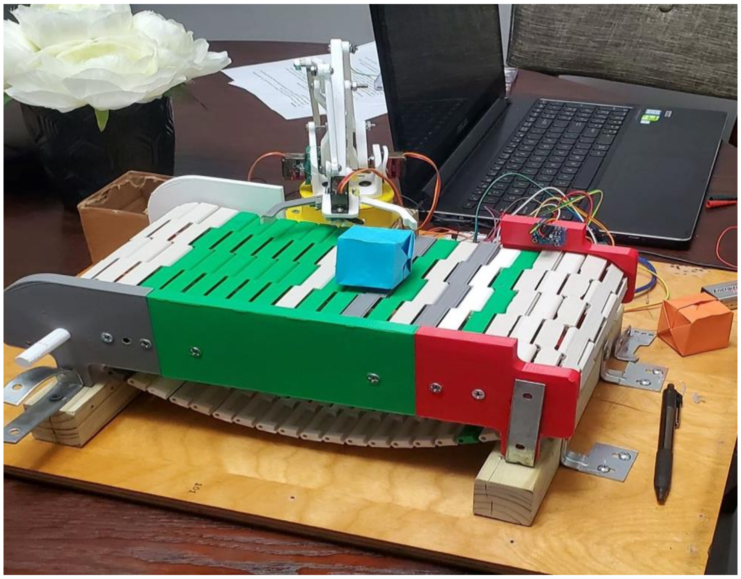

Figure 8. Final product of a modular conveyor belt with a robotic sorting

We hope to provide future students a better understanding about a crucial part of the engineering industry which is the conveyor belt . We also expect to face many challenges when building this prototype, especially when it comes to coding the sorting operation for the robotic arms. Although we are well versed in machine language, network theory and computer architecture, the actual programming of a functional prototype for something of the scope of this study will pose an expected challenge as a physical implementation such as the one required by this study is something we haven't done. Overall, programming for both systems will have to be separate as first, as the conveyor belt system will require separate proprietary programming from the robotic arm. Ultimately, we will attempt to implement both devices with the same Arduino board. We are very hopeful for the results of our prototype and look forward to presenting our findings with our scholar peers.

Bill of Materials

The overall project cost was drastically reduced after opting to reduce the scale of the prototype to fall within the allocated budget of the project. Instead of constructing a metal frame with a prototype closer in size to the full-sized proposed conveyor system, it was we decided to utilize the 3D Printers that are available to students in the department. It was also decided to opt for a more affordable motor that fits the new scale for the prototype. Therefore, a 126-rpm servo motor was used to drive the prototype module. In addition to this main servo motor, additional servo motors were needed that are more precise and smaller so that students may implement the robotic arms that sort through the different materials being transported in the conveyor. Student discussed whether it would be advisable to use a Raspberry Pi or Arduino microcontroller board for the project, as both are very capable for the project. The Arduino was already available in the department as the students learn it in the microcontroller class, therefore it was decided that would be the best option. The overall cost of the prototype is expected to be $128 as seen on Bill of Materials (BOM) listed on Table 1.

Table 1. BOM for Proposed System

Item	Description	Price
1	126 rpm Servo Motor (Belt Drive)	$15.00
2	Arduino UNO	$20.00
3	TCS230-TCS3200 Color Recognition Sensor x2	$16.00
4	10 pk Servo Motors (Robotic Arms)	$27.00
5	Miscellaneous (Bolts, nuts, wood scrap) & shipping	$50.00
	Sub Total:	$128.00
	Following items are provided by the University	
	MakerBot Replicator with Filament	$2500
	Grand Total*: *(*) Students suggested low-price vendors are Home Depot, ServoCity.com for DC motor, ball bearings and 6" stainless steel D-shaft and Amazon.com for Arduino, color sensor and servo motors.*	$2,628

Conclusions

This project provided opportunities for a group of senior students in a 4-year engineering technology program to become acquainted with the actual process of manufacturing a robotic arm-controlled conveyor belt system. The initial objective was to build a larger-scale system however the limitations on time and budget led to produce and operate a prototype module. Although the conveyor belt was a prototype module that did not show the effects of actual weight changes in the conveyor belt system, yet it did provide students a glimpse of understanding what they would expect from industrial size conveyor belt systems. A continuous improvement of this project would be designing and building a larger scale conveyor belt system without using 3D printed parts. This may provide a product with less life and sturdiness than an actual metal frame system. A larger-scale would also mean a larger size electrical motor with high starting torque and variable speed features. The links produced by a 3D printer are only modulable by length as smaller chain links the width could also be adjusted meaning that even more machines could use the exact same belt. The module is being used as an effective demonstration unit in the Control Systems Technology class.

References

[1] Ananth Konakalla N.S.A., Rakesh V., Viswesvarao P.K., "Design and Selecting the Proper Conveyor Belt", *International Journal of Advanced Engineering Technology*, Vol 4, Issue II, April-June 2013, pp. 43-49.
[2] Conveyor Roller Systems since recorded history, techspex.com, https://www.techspex.com/blog/post/conveyor-roller-systemssince-recorded-history, retrieved on March 1, 2021.
[3] Stommel, M., Xu, Weilliang, "Learnability of Moving Surface Profiles a Soft Robotic Sorting Table", *IEEE Transactions on Automation Science and Engineering*, 13(4), October 2016, pp 1581-1587, DOI: 10.1109/TASE.2016.2570208.

[4] Tsai, M.C., Lee, C.H., "Tracking Control of a conveyor belt: Design and experiments", *IEEE Transactions on Robotics and Automation*. 12(1):126-131, February 1996. DOI: 10.1109/70.481757
[5] Guelpa, V., Laurent, Guillaume J., Dahroug, B., Le Fort-Piat, N., "Modular Contact-free Conveyors for Handling Planar Fragile *Objects", IEEE Transactions on Robotics* , February 2017, Vol. 33 Issue 1, p92-101. DOI: 10.1109/TRO.2016.2623340.
[6] Chitikeshi, S., & Dhali, S. K., & Odell, B., & Jovanovic, V. M., & Lin, C. Y. (2020, June), *Curriculum Development for Robotics Technology Program* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2—34365.
[7] Kwon, Y., & Rauniar, S., & Chiou, R., & Sosa, H. (2007, June), *Remote Quality Control Integrated with Internet Based Robotic Systems* Paper presented at 2007 Annual Conference & Exposition, Honolulu, Hawaii. DOI: 10.18260/1-22080.
[8] Padir, T. (2009, June), *A Portable Workcell Design For The Robotics Industry* Paper presented at 2009 Annual Conference & Exposition, Austin, Texas. 10.18260/1-2—5209.
[9] Grey Orange Linear Sorter – Revolutionizing Automated Sortation (2016). Retrieved from https://www.youtube.com/watch?v=n9I_IM8RjRo
[10] The Arduino Nano-Driven Robotic Arm with Smartphone Control, Diyode Magazine published in Australia. Retrieved from https://www.thingiverse.com/thing:3534566
[11] Modular Plastic Conveyor Belts https://www.mknorthamerica.com/Products/modular-plastic-belt-conveyors/ Retrieved on January 15, 2021.
[12] Thingiverse.com. "Robotic Arm by SuperRachu", Thingiverse, www.thingiverse.com/thing:1721356 retrieved on January 15, 2021.

Appendix A: Main Code

```
#include <Adafruit_TCS34725.h>


#include <Servo.h>    // servo motors
#include <Wire.h>

// Define the variables:
uint16_t r, g, b, c, colorTemp, lux;
int servopinbase = 9;
int servopinleft = 8;
int servopinright = 5;
int servopinarm = 6;
int color = 0;
int count = 0;
int motorPin1 = 7;
Servo Servo1, Servo2, Servo3, Servo4;

Adafruit_TCS34725 tcs = Adafruit_TCS34725(TCS34725_INTEGRATIONTIME_700MS,
TCS34725_GAIN_1X);  // Initialise with specific int time and gain values:
```

```
void setup()
{
 pinMode(motorPin1, OUTPUT);
 Servo1.attach(servopinbase);
 Servo2.attach(servopinleft);
 Servo3.attach(servopinright);
 Servo4.attach(servopinarm);
 // Begin Serial communication:
 Serial.begin(9600);
 // Check if the sensor is wired correctly:
 if (tcs.begin()) {
   Serial.println("Found sensor");
 }
 else {
   Serial.println("No TCS34725 found ... check your connections");
   while (1);
 }
}

void loop()
{
   // Get the raw sensor data for the red, green, blue and clear photodiodes:
   tcs.getRawData(&r, &g, &b, &c);
   // Calculate the color temperature using all the sensor data:
   colorTemp = tcs.calculateColorTemperature_dn40(r, g, b, c);
   // Calculate lux using red, green and blue sensor data:
   lux = tcs.calculateLux(r, g, b);
   // Print the data to the Serial Monitor:
Serial.print("B: "); Serial.print(b, DEC); Serial.print(" ");
Serial.print("C: "); Serial.print(c, DEC); Serial.print(" ");
Serial.println(" ");


  if(c < 1499){ //default
       digitalWrite(motorPin1,HIGH);
    Servo4.write(100);
    delay(1000);
    Servo1.write(120);
    delay(1000);
    Servo2.write(75);
  }

  if(c >1500){ // white 1
  delay(100);
  Servo4.write(200);
  delay(500);
  Servo2.write(150);
  delay(500);
  Servo1.write(0);
  delay(500);
  if(b > 20000){
    Servo4.write(0);
    delay(1000);
    Servo1.write(200);
    delay(1000);
  }
 }
}
```