Technology almost 4.0 application in developing a conveyor belt with low-cost, reused and accessible materials for bagging grains

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Abstract

With the technological development of a new class of wastes, the technological ones were created. Many times this waste is not processed correctly, having its hazardous disposal. Thus, recycling these materials is an alternative to end specific equipment. This work used this approach to develop a low-cost, affordable second-row conveyor belt. The conveyor belt was designed to bag, weigh, and monitor different volumes in a grain silo. Such equipment is of interest to smallholder applications as well as the integration between different areas of the Biosystems engineering course.

Keywords: Agriculture 4.0, Remote Sensing, Transdisciplinaridade, Complex Systems.

1. Introduction

Automated or integrated intelligent computing agroindustry machinery is not widely used equipment for small farmers. The development of such equipment for process optimization, customized, innovative, and even low cost can meet both the needs of farmers and engineers with current technologies 3.0 and 4.0. Thus, integrating agricultural use equipment with IoT (Internet of Things), Big Data, Additive Manufacturing, Artificial Intelligence, and embedded sensory technologies.

Brazil is one of the largest exporters of grain in the World Market [1], and its challenge is to develop and incorporate these technologies in its industrial and agronomic fields. Although there is a government agenda for Brazil's preparation for challenges 4.0 [2], the steps of these changes are still small and arduous. An effective medium- to the long-term alternative is in higher education as a foundation for change and support for innovation.

The undergraduate Biosystems Engineering course has as one of its pillars the addition of 4.0 technologies to biological systems for sustainable development in land use, environment, agriculture, and industry. In this scenario, students and teachers of the Biosystems Engineering course at São Paulo State University (UNESP), designed and developed a low-cost prototype of a conveyor that automatically bags, weighs, and monitors grain.

2. Background

2.1 Conveyor belts system

A conveyor is a mechanism used to move large volume items or materials within a facility [3]. We can have two types of transporters, non-motorized and motorized. Regarding the latter, there is an integrated system such as chains, belts, rollers, motors, and other mechanisms that realizes the propulsion of the object. The non-motorized movement is made by human power or by gravity [4]. In this work, we highlight the conveyor belt system because they are widely used in agricultural processes.

The belt is one of the most critical components of the conveyor because it is moving and where the material settles. The choice of the belt occurs due to the characteristics of the material to be transported, roller type, travel time and, maximum tension [5].

Conveyor belts are of the following types, smooth, ribbed, sandwich, lifter, and sliding. It can be flat, U-shaped, and circular shape. With different operating inclination angles, application type, coating rubber, and conveying surface [6]. Curved conveyor belts provide more dynamism and efficiency to production lines as they feature more flexibility and centrality to integrate various components into the system.

2.2 Transdisciplinarity in the construction of the didactic prototypes.

Basarab Nicolescu was one of the first authors to work on concepts of multidisciplinarity, interdisciplinarity, and transdisciplinarity in the mid-twentieth century [7]. The author reports that the availability of information and knowledge beyond all that manipulated in previous centuries. Currently, we are in the era of complex systems, connected by technology 4.0. A system is a set of relatable elements. A system is complete when, from the interactions between its constituents - without interference from a controlling center - a new behavior emerges.

Bertalanffy, in 1973, developed the general systems theory (TGS), an interdisciplinary theory that aims to overcome the particular and exclusive problems of each area of knowledge. It focuses on the development of general principles and models suitable for use in various scientific fields [8]. The study of complex systems requires a multidimensional analysis of the subject content. In these, there is the need for interconnections of both knowledge and expertise that not only leads to transmission techniques and content but transcending disciplines.

Transdisciplinary is in the study of a problem with its multiple planes of analysis of reality and context. Additionally, it addresses the dynamics of relationships between different planes and the systems that make up the world. In this context, the interaction between disciplines can encourage the emergence of new techniques, methodologies, and knowledge in traditional practices that would take considerable time to be discovered or acquired. The involvement of students in the development of the conveyor belt goes beyond the acquired interdisciplinary content. However, it has tangency in all disciplines that integrate the Biosystems Engineering course.

3. Material and methods

Initially, the conveyor belt construction process was made a previous study to define the materials, viability, and conditions to execute the process. We emphasize here that the vast majority of the materials used are affordable and inexpensive.

3.1 The project

Highlighting the use of low-cost materials, we use a set of chain-connected bicycle ratchets as gears. A 3D project was designed using Autodesk's Inventor Professional 2017 software, build 142, as shown in Figure 1a-b. The conveyor belt was defined as 60 cm in diameter, large enough to attach a grain silo. Eight bicycle ratchets positioned, as shown at points A-G in Figure 1c, were used.

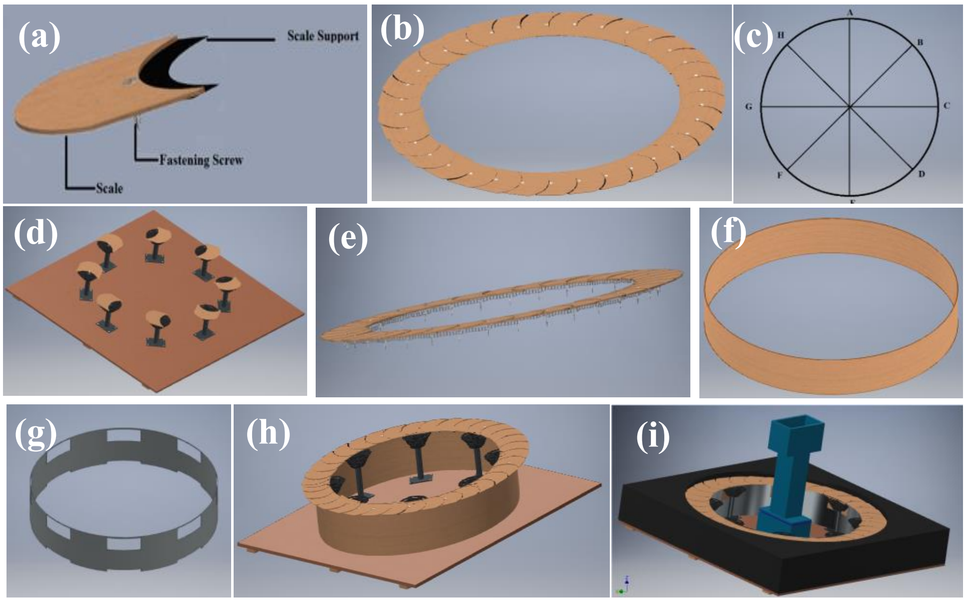

Figure 1 – Here, the 3D prototype is presented in (a) Scale model; (b) Circular Base of Scaled Conveyor Belt; (c) Turnstiles on a wooden base; (d) Ratchets and scale positioning; (e) Connected scales and fixed bicycle chain; (f) Wood plate; (g) Sheet metal; (h) and (i) Conveyor belt structure overview, respectively.

The conveyor belt gear system consists of a motor, ratchet, and bicycle chain. The chain was fixed on the scales and placed on the outside of the turnstiles. An electric motor, automotive windshield wiper, was connected to one of the ratchets and, when activated, drives the chain; consequently, the other ratchets start moving, as shown in Figure 1d-e. It was added to the project two plates, one of wood and another metal, to improve the stability of scales. Figure 1f-g shows these wooden boards with a diameter of 80 cm and a height of 15 cm, while the metal plates are of zinc with a diameter and height of 60 and 15 cm, respectively. The final prototype is shown in Figure 1h-i. The project used reuse of materials and at no cost, such as plywood (MDF), 12 mm, zinc plate, turnstiles, and bicycle chains, metal pieces, meat grinder, parts of printers, and a gallon of water.

3.2 Conveyor Belt Assembly

The assembly of the machinery was performed in the following steps:

I. Cutting and assembly of the support structure for the treadmill: 1.20m extended quadrangular region;
II. Fixation of the turnstiles according to the subdivisions calculated in Fig.1b;
III. Positioning of the metal plate inside the turnstiles;
IV. Fixation of four threaded bars for the stability of the conveyor belt;

V. Allocation and stabilization of the ratchet currents;
VI. Motor connection in one of the ratchets.

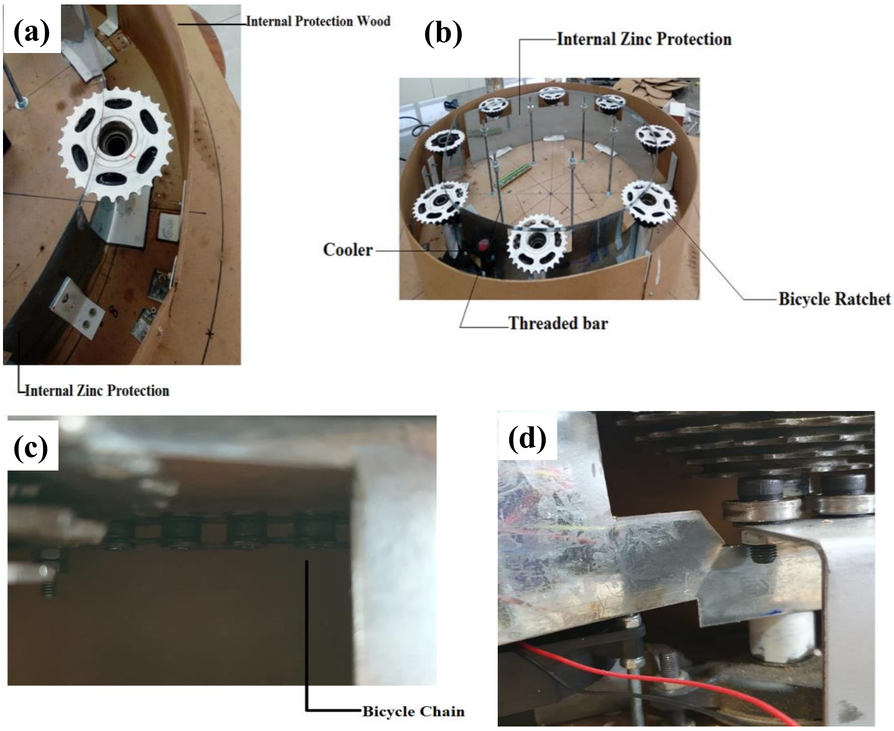

Figure 2 – Pictures depicting the steps of the assembly process in (a) and (b) parts I through IV while in (c) and (d) parts V and VI are shown.

Finally, a meat grinder was used as an endless thread, for bagging the grain, was fixed in the center of the conveyor belt. In this position was fixed the scale structure, a central top, the gallon of water - simulating a silo and automation and control devices.

Figure 3 – Final assembly of the conveyor belt with all items attached.

3.3 Process Automation

After theoretical and practical analysis, we use the following sensors and actuators:

(*i*) E3F-DS30P1 photoelectric sensor, fuzzy detection, PNP, normally open, supply voltage 10 to 30 Vdc, 300 mA output current, minimum actuation distance of 2 mm and the maximum sensing distance of 10 to 30 cm. Two photoelectric sensors were used, one for the object on the grain weighing rail and one below the silo for grain bagging, Figure 4a-b;

Figure 4 - a) Photoelectric on rail for weighing movement; b) Photoelectric in the bagging of grain; c) Electric motor for Silo; d) Engine allocated to one of the turnstiles; e) Rion of HI Tecnologia; f) 12V Beehive Source; g) Capacitive Sensor; h) Reducing motor; i) Precision digital balance and, j) Limit switch.

(*ii*) MABUCHI electric motor of 12V, eight teeth. Two motors were used: a) To move the infinite thread belonging to the meat grinder and b) In one of the ratchets to move the belt, as shown in figure 4c-d;

(*iii*) HI Technology Programmable Relay and Remote I / O, Rion model (HIO115), 10 to 30 Vdc supply voltage, with 8 digital inputs, 4 digital outputs, 3 analog inputs, with 1 encoder, 2 fast counters and 1 PWM, Ethernet or serial cable communication, Fig. 4e.

(*iv*) Switching Power Supply, EJCF - S120, 12 V, 10A and 120W for powering the entire system, Fig. 4f.

(*v*) Capacitive Proximity Sensor from the Sensorbras brand, PNP, with a sensory distance of 5 mm, with sensitivity adjustment, powered with a supply voltage of 10 to 30 Vdc. This sensor will control the amount of grain in the silo, Fig. 4f.

(*vi*) GM-25-BLA370-10-12D8 12V reducer motor for moving the rail that will lead the pot with the beans to the weighing place, Fig. 4g.

(*vii*) Clink brand SF 400 digital weighing scale, Fig. 4i;

(*viii*) Limit switch for process completion;

(*ix*) buttons to start and stop the machinery and emergency.

3.3.1 Ladder Programming

The programming was done in SPDSW, from HI Tecnologia, version 4.4.05, following the following steps:

I) It consists of turning the treadmill motor on / off through a main switch and activation of the silo photoelectric sensor.

II) Recognition of the container that will receive the grain by the photoelectric sensor positioned in front of the silo outlet. If the pot is recognized, then the response is stored with the value 1, otherwise 0.

If 1, the crawler motor is stopped, the silo motor starts, and the grain dump begins for a time determined by the programmer. Upon completion of this time count, the treadmill returns to operation, and the container continues its course. In this step, we have the silo photoelectric sensor interruption and the scale photoelectric activation

III) Recognition of the container with the grain by the photoelectric sensor positioned on the scale. If the pot is recognized, the treadmill motor will stop, and the swingarm motor for the balance - left steering - will start for a while. At the end of this time, the container waits on the scale (for a period) to measure its weight. After weighing, the drive arm motor is started - now in the opposite direction - forwarding the container to the belt again. In this phase, there is the inactivity of the photoelectric sensor of the balance and activation of the limit switch.

IV) Conveyor belt motor is restarted. The container continues its path through the belt until the limit switch is activated, finishing the process.

There is also an emergency button that, when activated, deactivates all sensors and actuators of the equipment. The device will reboot only after activation of the master switch. The code is shown in Fig.5.

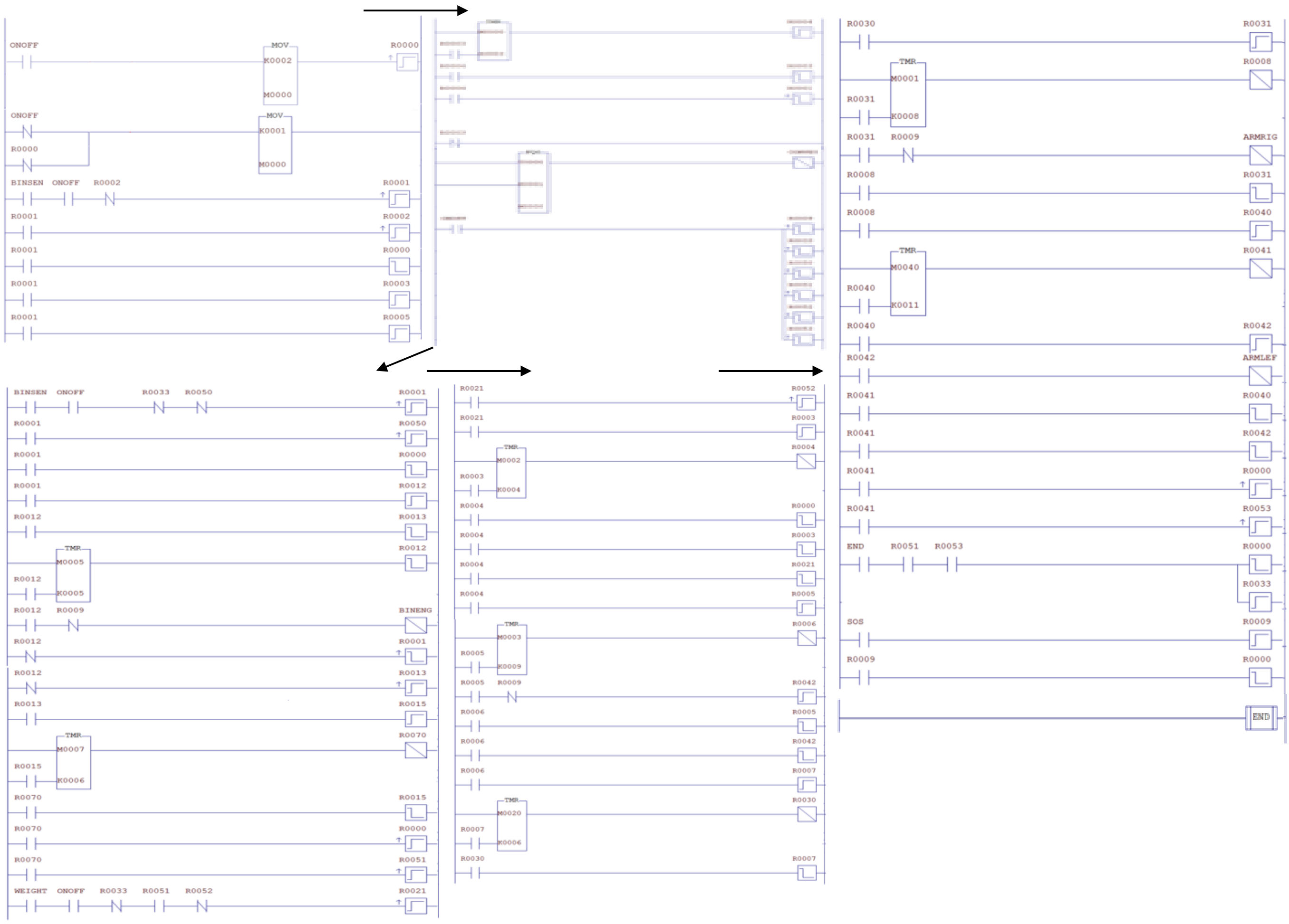

Figure 5 – Conveyor Programming.

3.4 The supervisory system

A supervisory system was developed using Elipse E3 software, version 4.8.352. This program was used to supervise the variables and devices attached to the conveyor belt, see Fig. 6.

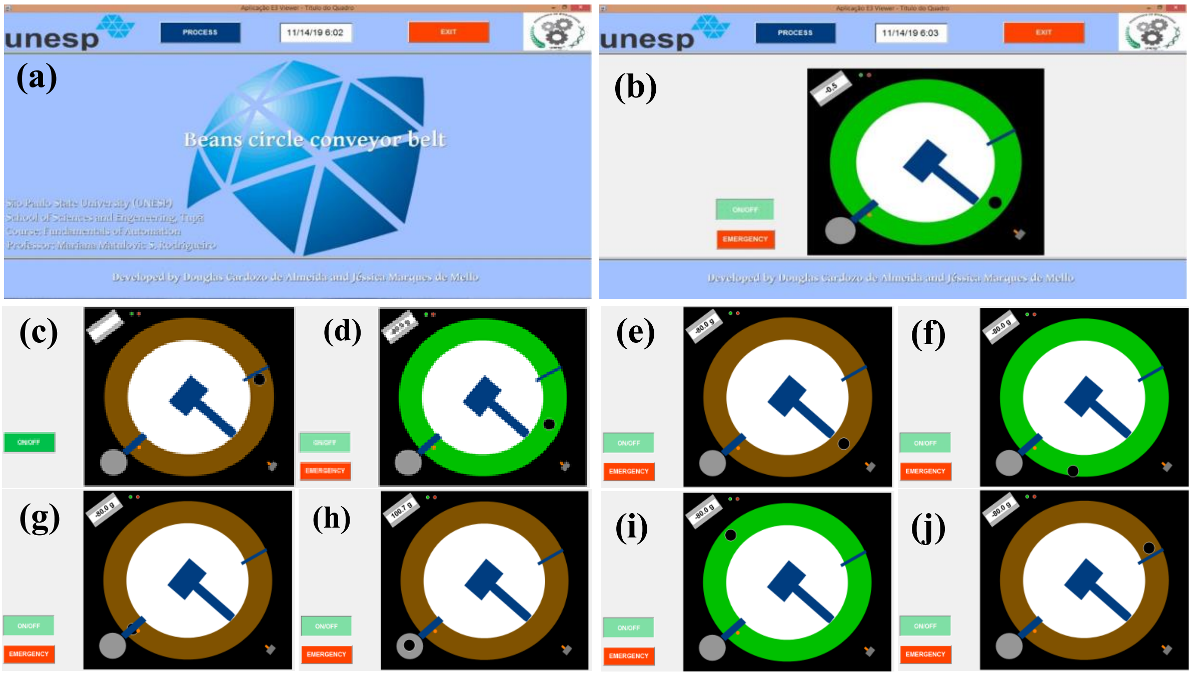

Figure 6 - The figure presents as different stages of the supervisory system (a) Supervisory initial screen; (b) Process Screen; (c) Process awaiting commencement; (d) Beginning of conveyor belt movement; (e) detection of the photoelectric sensor, treadmill and dump grain; (f) movement after bagging; (g) Scale photoelectric sensor detection and start of arm movement; h) weighing; (i) After weighing, one return to operation and (j) End point.

The Process screen shows the conveyor belt with the silo, the photoelectric sensor in the silo direction, the grain weighing conveyor and the machine display, Fig. 6a-b. In a sequence of images, all programming steps are supervised as shown in Figures 6c-j:

(a) Supervisory initial screen;
(b) Process Screen;
(c) Process awaiting commencement;
(d) Beginning of conveyor belt movement;
(e) detection of the photoelectric sensor, treadmill and dump grain;
(f) movement after bagging;
(g) Scale photoelectric sensor detection and start of arm movement;
h) weighing;
(i) After weighing, one return to operation;
(j) End point.

4. Results and Future work.

Linking technology and sustainability is something that companies are investing in smart computing want. The construction of machinery with disposable materials, mainly digital and computational waste - such as those used in this prototype - highlights at least three essential points:

1) A large volume of technological waste generated;

2) Technological innovations are not capable of generating sustainable solutions;

3) The sustainable act is born of the conscience of each developer, buyer, and entrepreneur that moves the market;

In this context, by turning waste into educational and practical devices for smallholders, teachers and students fulfill the mission assigned to Biosystem Engineers to develop and incorporate intelligent computing into the sustainable use of land, animal and plant systems, agriculture, and agriculture. Industry. In order to make the prototype even more accessible, the programmable logic controller can be exchanged for an MSP430FR5949 microcontroller, and the entire machinery supervisory system available for mobile applications on the android platform.

5. Acknowledgement

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