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Clothes Folding Machine

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Executive summery

KACC idea comes from daily observation of the young generation. They transfer their clothes from chair to bed in the morning and put them back at night. The untidiness bring along several negative impact such as disorganized, less productive, etc. Therefore, this document is to propose an automatic clothes folding machine.

KACC folding machine is targeting two main market, home and industry use. The machine will be sold as a piece of home appliance. The industrial customers include apparel manufacture, hospital related facility, hotel and retirement home. In 2015, around 9% of the Canadian senior citizens live in retirement homes. In Quebec, about 18.5% of the seniors live in 1,300 retirement homes, and the number keep growing over the year. As a result, the machine is able to assist elders in the future. According to a report in 2012 from the House of Commons, Canada is facing the challenge of labor shortage, and went on addressing barriers to filling low-skill jobs that create a perfect timing for a folding machine.

There will be four main features in this machine, which include fetch, stretch, fold, and dispense. All of the features do not require human interaction. The project costs approximately 676.71 dollars and large portion of the funding will be provided by ESSEF.

The KACC team is made up of a diverse group of engineers, with member concentrate on computing science, system and electronic option. The estimate time-span for this project is 11 weeks with two phases. Phase alpha which last for ten weeks and the team is going to focus on design, assembly and debug. The second phase, the beta phase, will be focused on optional modifying such as improving the user interface, website and promotional movie.

The KACC automatic clothes folding machine might as well be the best investment due to the benefit to the low-skilled labor, and the marvelous size of the potential market.

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1. Introduction

"Inspiration is a guest that does not willingly visit the lazy."

- Pyotr Ilyich Tchaikovsky.[1]

This sentence precisely explained the invention history for human beings. Frankly speaking, most of the inventions are designed to make people's life easier in order to satisfy the needs of being lazy. People put wheels on our luggage to make travelling effortless. They invented escalator to make climbing-up easier than ever. They created microwaves to save time and energy when cooking. Innovative ideas come from lazy people to make things simpler.

Now, it's the time for a folding machine to satisfy the laziness of human beings. People can now leave a pile of clothes and let the folding machine to do the boring and time-consuming folding work. Moreover, the folding machine has huge social benefits. With decreased number of workforce caused by aging of population, folding machine is helpful with the lack of human power in some industries such as health care institutions, hotels and clothing stores.

The objective of KACC project is to design and develop a fully automatic machine that can perform clothes folding automatically. The designed folding machine performs several functions that are essential for clothes folding. In details, functions include grasping and stretching a clothing item, followed by folding and transporting the clothing into a designated area. The operation mechanisms will be constructed using mechanical and electrical components such as servo motor, PCB board with built-in microcontroller and different sensors such as ultrasonic sensor and pressure sensor.

This document is a proposal clearly describing our product, including its functionality, detailed working process, predicted building cost and project schedule. Additionally, alternative approaches to the specific mechanisms will be discussed and best solution will be explained. Detailed company profile and logo design, as well as sources of budget and funding will be provided in this document.

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2. System Overview

The design of the system involves five features (Figure 1). First, the machine is able to fetch (grab) and put one clothes onto a desired area. When the machine senses it was done, it stretches the clothes to prevent crinkles. The machine performs the folding mechanism after the stretching finished. Finally, the folded clothes is dispense to a specific area. The design includes a single LCD display to alert the user once there are no more clothes can be folded.

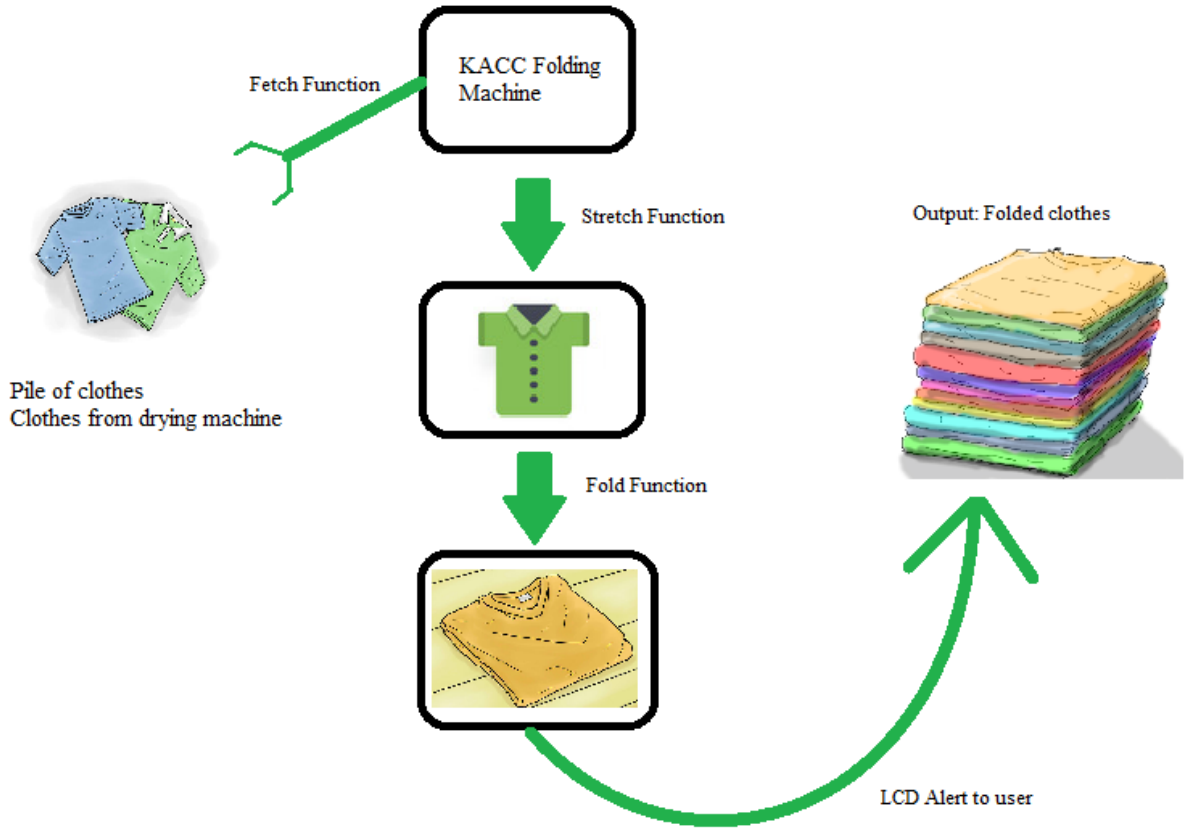

Figure 1. KACC Folding Machine Procedure[2][3][4]

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System Overview (Continued)

Figure 2 shows the machine flow diagram. When KACC Folding Machine is turned on, it will perform the fetching, stretching, folding, and dispense procedure. When the machine is on, it will try to fetch another clothes. A new clothes is fetched after the whole procedure finished. Therefore, this machine does not support sequentially working when another clothes is being folded.

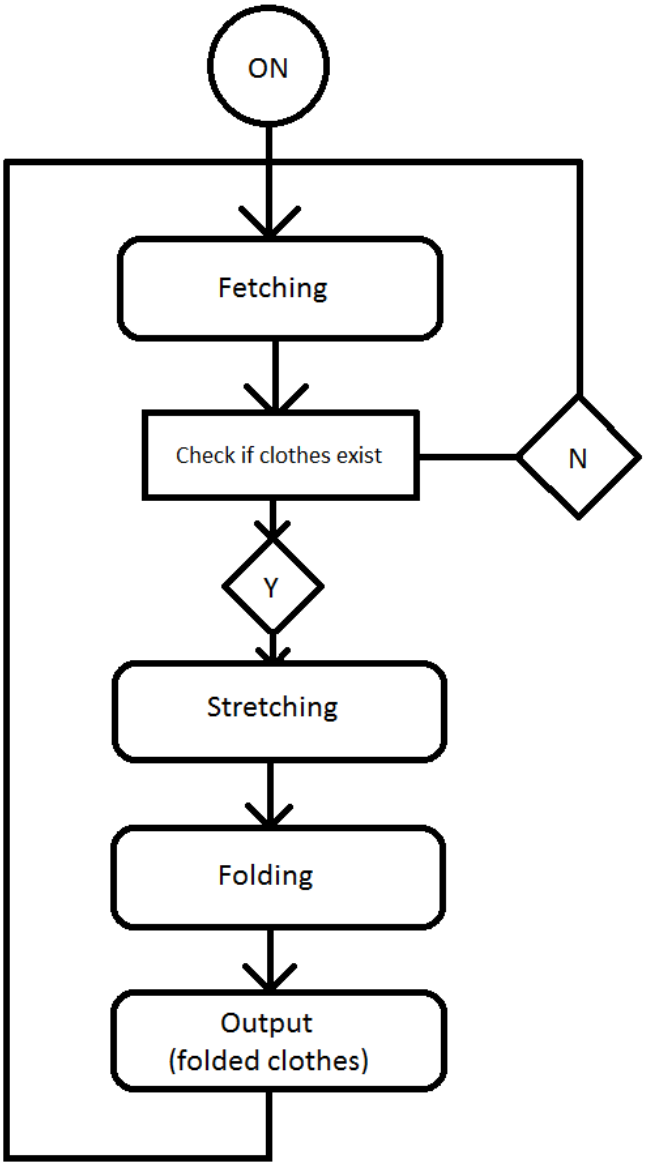

Figure 2. Flow diagram of KACC Folding Machine (Turned on)

3. Possible Design Solution

The design of the machine involves many mechanical designs. The design of the whole system is separated into four major features: fetch, stretch, fold, and output. The biggest challenge of this design is to fetch the clothes. Some of the possible solution to encounter that is listed below.

3.1 Pile of Clothes on a Bar

In order to fetch the clothes into the machine, the clothes must have a common standard. One of the possible solutions is to require user to put all the clothes on a hanger bar. The machine arm, which is powered by a motor, is able to grab the horizontal center of the clothes and perform the stretch mechanism. However, this design is complicate because of the different height of the hanger bar locate.

3.2 design around conveyor belt

Another possible design approach is to build an electrical powered conveyor belt that has approximately same width as the machine itself. The conveyor belt will be transporting clothes into the machine. After the robotic arm grabbed and transferred the clothing item onto the belt, the robotic arm will stay in position for set amount of time to make sure that the clothing item is stretched evenly. Then, the clothing item will be released by robotic arm and will be transported by the conveyor belt into the machine. Followed by which the clothing item is folded and transferred onto a designated area surface.

The approach of using conveyor belt has its advantages and disadvantages compared to other solutions. The use of conveyor belt has both stretching and transporting functions. The downside of such design is that the completed design would take way more space for its operation, which makes the design less likely to be a home use product.

3.3 Alternative design for detecting

One of the major obstacles is to detecting the object to be folded during the stretch phase. A way to solve this issue is to embed sensor into the folding board. Those sensors should be placed at certain position such that it can detect the clothes is placed on the sensor. Once all the sensors are covered by the clothes, it can process to the folding phase. In case of failure, at least one sensor should report the error and the machine can correct the clothes until the clothes is placed properly.

3.4 Different folding mechanism

This folding mechanism is different from the standard. The machine first folds the clothes to half horizontally. After that, it folds both sleeves inwards. Then it folds the clothes half vertically as a rectangle. However, this folding method is not the standard procedure.

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4. Proposed Design Solution

The final design is stated as below, keep in mind that the final result might have slightly different as illustrated.

- The whole system will be controlled by two microcontroller (in this case, two Arduino Uno), that is capable of communicating with each other using I^2C connection. The first Arduino will be in charge of all the sensors that are used to detect the incoming garments. The other one will be in charge of all the servo and DC motors.
- The fetch mechanism will be designed as a system that is efficient to pick up clothes. At the same time, the machine is able to distinguish individual garments. The current propose is to build a robotic arm with an agile tip. However, a wheel shaped transfer belt is also considered at this moment. KACC decide the arm design as the primary solution and the belt approach as the alternative.
- The stretch function is the most challenge feature in the whole system. KACC decide to use the 3.3 detecting design for.
- The folding mechanism is very straight forward at this point. KACC will use the classic folding board and the standard clothes folding mechanism. The standard folding method is to fold the clothes from left and right. Then fold it horizontally.

For each of the design, KACC always have at least one back-up solution to the problem.

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5. Benefit & Risk

Since the machine is fully atomized, it will work on its own without human supervised for most of the time. As a result, people can work on their own business instead of folding a clothes. This is one of the most significant benefit. However, it can also led to a fatal error. For example, if the clothes stuck in the fetching stage, the machine might tear up the clothes. When the motor are running constantly under friction or pressure, it might cause overheat, or even fire hazard.

Being a home appliance means the environment is close to children and pet. They might put their hand in the machine because of the nature of curiosity. To prevent the tragedy from happening, the design may need some safety features to keep it out of reach from young children and larger pets. Also an emergency break should be available for the final design.

Besides of the mechanical risk from the machine, KACC Folding Machine also has an impact to the society. The older generation currently with low-skilled job may be laid off. They may become unemployed for a period of time due to their low education. On the other hand, it generates an opportunity to the younger generation to learn high tech. The young generation understands the demand of the low-skilled job decreases such that they have a higher motivation to change themselves compare to the older generation.

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6. Research Rationale

The market are dominated by large number of low-skilled and repeated labour currently. Individual workers are less efficient than a machine. When a company uses an automated machine, it only requires regular maintenances instead of supervision. Therefore, company is willing to pay for a machine rather than a salary worker.

The existing machine in service are very costly to afford, which is 5,000 dollars per unit. A normal household is not willing to pay for such machine. Moreover, the enormous size make it impossible to place in any room.

In comparison, the clothes folding machine in the market requires a full-time operator. The folding process also need to be under constant supervision. On the other hand, instead of building a work station, we propose a smaller, less costly, and fully automated machine that can fit in a laundry room. This propose can effectively fill out the blank of the clothes folding machine for household as well as competition with the factorized industrial folding machine.

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7. Sources of Information

Our team obtains most of the information from the internet, user manuals of the hardware, and previous document samples. The internet is a valuable source to obtain some information such as the instruction of how to use the hardware, the mechanical procedure to perform the KACC Folding Machine features.

Additionally, we have obtained essential instructions and knowledge from some of our professors and teaching assistants, especially the prototype design ideas approval. At the same time, we are getting help and valuable suggestions from our peer engineering students. All these sources of information helped us achieve the goal on our project.

KACC also research on the market value of the product. KACC member talk to some potential users for the new features. Those customers' opinions are also important to KACC growth and product development.

Finally, the most of information comes from research of our own team members. Undeniably, the previous internship experiences of three group members contribute a lot to KACC project prototype constructing. KACC team members are composed with experience in software quality assurance testing, professional knowledge of web design, exceptional skills of mechanical design and solidworks drawing.

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8. Budget & Funding

8.1 Budget

Table 1 shows the estimated budget of the whole project. There are four motors and gears to control the arm as an actuator. One of the microcontrollers controls the sensors, one controls the motor and the last one controls the feedback display. The electric components include wire, sensors, and IC chip. KACC decides to host a website to promote the product that is listed below.

Table 1. Budget outline of the project

Equipment List (Brand)	Quantity	Estimated Unit Cost
HS-5645MG Digital High Torque servo motor (Hitec)	4	$50.24
HS-5496MG Digital HV Karbonite Gear servo (Hitec)	4	$29.16
FlipFold Board (Clothes folding board)	1	$20
Arduino Uno USB Microcontroller Rev3	3	$26.99
6V - 12V Nimh/Nicd Smart Charge x1 (Tenergy)	1	$28.14
20x4 Character LCD Display (Adafruit Industries)	1	$25
Electric Components	various	$20
Metal/Wood Material	various	$150
Promotional Website	N/A	$30
Total Cost:		**$676.71**

8.2 Funding

Since building such a machine requires many materials such as metal and wood, it is the major cost in the project. In order to decrease the cost and be environmental friendly, KACC considers using reusable wood and metal for the prototype.

KACC is in the process of applying for the ESSEF which is the only support. KACC team members are willing to spend on the project if insufficient fund occurs. KACC also plan to sell the product to the industry in the future because the requirements of automated lifestyle increase.

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9. Schedule

Table 2 shows the timeline of the project in the following three months. KACC team member is going to purchase the components for the project concurrently with the proposal. Our team will start testing the product once it is in developing stage. As a result, it can maximize the efficient.

Table 2. Schedule from Gantt Chart

Name	Begin date	End date
RESEARCH	15/09/15	05/10/15
PROPOSAL	15/09/15	30/09/15
COMPONENT PURCH...	25/09/15	29/09/15
FUNCTIONAL SPEC	01/10/15	26/10/15
DESIGN SPEC	02/11/15	11/11/15
ASSEMBLY	29/09/15	03/12/15
INTEERGRATION / TES...	02/11/15	11/12/15
DEBUGGING / MODIFI...	25/11/15	11/12/15
DOCUMENTATION	15/09/15	15/12/15
WEBSITE	26/11/15	15/12/15
PROCESS REPORT	16/11/15	24/11/15

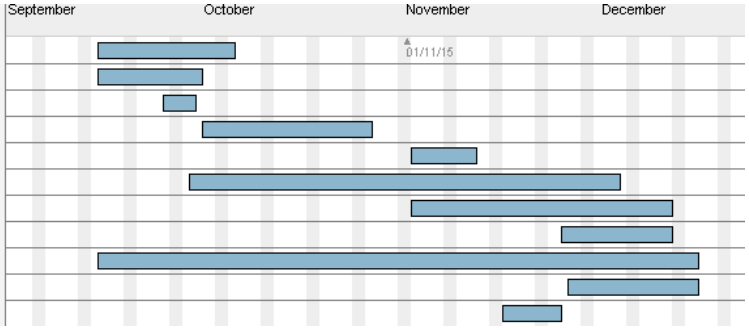

Figure 3 shows the Milestone diagram that is created from the Microsoft Excel. The milestone without a specific time will be decided with professor and teaching assistances in the future.

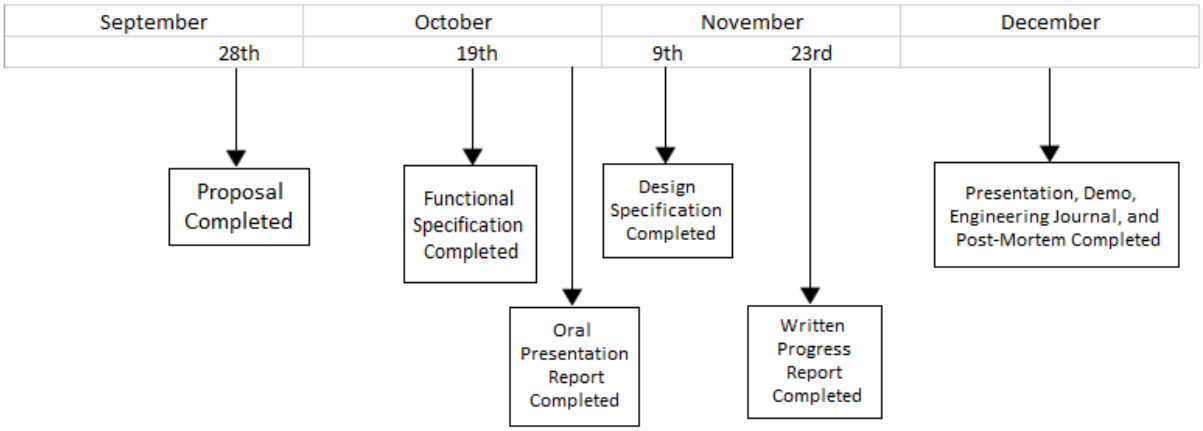

Figure 3. Milestone

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10. Team Organization

KACC is formed by four engineering students with different skills and talents. Four of us have different experiences in various areas. As a result, each member has his own expertise to achieve the common goal for the KACC folding machine. Besides that, KACC team member can learn from other members' expertise.

KACC team member has different role in the corporation. Jiahe Kevin Zhou, KACC Chief Executive Officer (CEO), as the team leader, will be in charge of the project final decision and supervises the project progress. Jiahe's main responsibility is to map out the project building progress and make sure the team is on schedule on every single task. Also, Jiahe is in charge of working with Solidworks for project modeling, including main structure, parts and assembly models. Ka Chun Wong, KACC Chief Financial Officer (CFO), manage the cost, budget control, as well as the documentation review. Ka Chun will cooperate with the rest of the team for the best cost efficiency. Zhiyong Charles Weng, Chief Operating Officer (COO), investigates and proposes any possible solution to the project. Zhiyong will collaborate with the crews bi-weekly and report the current progress. Minchao Chen, Chief Technology Officer (CTO), is mainly in charge of the web design, server, and operational issue in KACC. The entire member in KACC assists with Charles Weng in order to find and decide an efficient and effective solution to the project.

KACC team holds regular meeting bi-weekly. During the meeting, team members communicate and discuss the progress of the whole project. Our team also uses group chatting application to ensure communication outside meeting time. In every meeting, the team discusses the engineering issue from the project, and the documentation details. Team members also organize activities such as dinning in order to build trust between KACC team members.

Since everyone has their own strengths and weaknesses, team member can fill out each other's' gap by interaction. This can ensure crew member, as well as the whole team maintain efficient and organized in solving problems. Moreover, individual members can learn and understand their weakness and improve their compatibility throughout the project. Each member is assigned with different task for productivity while at the same time process cohesively to avoid being disorganized.

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11. Company Profile

Jiahe Kevin Zhou - Chief Executive Officer (CEO)

Kevin has spent 5 years at SFU studying Systems Engineering, as well as SIAT artistic design minor degree. With the previous IT coordinator internship at Hewlett-Packard, Kevin has gained sufficient experience of working effectively in a team. Kevin is experienced in Solidworks prototype design and drawing. Being the team leader, Kevin serves and coordinates the team well.

Ka Chun Wong (Allen) - Chief Financial Officer (CFO)

Allen is a third year system engineering student in Simon Fraser University. He worked at Global Relay Communication Inc. as a QA analyst in the last Co-op term. He is experienced in software testing and coding. Allen is interested in embedded system and willing to learn. He worked on both HC12 and Zedboard during his learning path. Besides of the technical side, he likes to do activities such as photographing, swimming, and hiking when he has free time.

Zhiyong Charles Weng - Chief Operating Officer (COO)

Zhiyong is an experienced forth year engineer who is currently concentrate on system option in Simon Fraser University (SFU). His expertise is in hardware and mechanical system. He has already worked on several other Arduino based project in the past few year. He is interested in robotic and computer programming. In his free time, he likes fishing and hiking.

Minchao Chen (Charlie) - Chief Technology Officer (CTO)

Charlie is a fourth year computer option engineering student at Simon Fraser University. He has years of experience in Web development and is an expert in IOS and Android development. He has also gained experience of electronic circuits through his university study. Charlie is also active in graphic and video design technique. On the other hand, he enjoys basketball and hiking very much.

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12. Conclusion

While KACC automatic folding machine is considered as an effective innovative solution to the problem of lack of employees in some industries, it is also convenient and user-friendly for personal home use to make folding laundry effortless. The final goal of our design is to make folding easier than ever before and bring benefits to people.

KACC proposed folding machine design would free people from manually folding clothes to save time and effort. KACC proposed solution is more cost effective on the market so that everyone can afford such a machine. To achieve the goal of cradle-to-cradle design concept, our proposed design is composed of reusable materials and environmentally friendly components and parts. The choice of reusable materials has also lowered our constructing cost of the product. KACC targets not only the industries, but also the machine that can use in everyone's home.

As illustrate in the previous section, the potential of this machine is wondrous. With the multidisciplinary engineering team, KACC Folding Machine improves in every version. KACC also promise to listen to the feedback from the users. KACC team members will improve their own skills to archive the common goal.

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13. Glossary

Home appliance[7] – Electronic devices that can accomplish household function (e.g., drying machine)

Low-skill jobs – Jobs that has a low salary and does not require any specific skills

ESSEF – Engineering science student endowment fund

Feature 1, **Fetch** – Mechanism that is designed to grab one clothes from a pile of clothes

Feature 2, **Stretch** – Mechanism that apply some forces to the clothes in order to prevent crinkles

Feature 3, **Fold** – Mechanism which involves some mechanical components to fold the clothes

Feature 4, **Dispense** – Mechanism that can output the clothes from the previous feature

LCD Alert – A feedback system involving a LCD display that can alert user

Arduino Uno – A microcontroller that is developed from Arduino and able to control sensors and motors

I²C[9] – Inter-Integrated Circuit, a low–speed peripheral integrated circuits between processors and microcontrollers

FlipFold Board – A board that can manually fold clothes

IC chip[8] – Integrated circuit chip, a set of circuits on a small plate (e.g., op-amp)

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