ME 4543 Mechatronics @ UTSA

Final hardware project: Hall of Animatronics Engineering Professor

1 Motivation

The project is inspired from Disney's Hall of President attraction. This is a stage show featuring all the US presidents as audio-animatronic (robotic) figures, some of whom deliver a choreographed speech. A video of the theme-park attraction is here (starting at approximately 16 min) https://youtu.be/KMn83d4tQp8?t=950

2 The objective

The objective of this project is to build an animatronic face that interacts (in some limited way) with the user. In particular, students will create an animatronics face of a professor from the Department of Mechanical Engineering (or in some cases the College of Engineering).

The student learning outcomes are as follows:

1. Ability to design a mechatronic system.
2. Ability to select sensors and actuators.
3. Ability to interface sensors and actuators
4. Ability to program micro-controller
5. Ability to successfully integrate microcontrollers, sensor, and actuators to create a functional mechatronic system.

3 Technical specifications

The overall goal is to build an animatronics figure of a professor that interacts with the user in some limited ways. For example, when the user waves the hand near the eye, a sensor will detect the motion and then respond by saying "Hello" and then say a punchline characteristic of the animatronics professor such as "Entropy is defined as..." or "The average score in the exam was...".

The technical specifications for the animatronics engineering professor are as follows.

1. **Animatronics character:** In order to represent the Professor, the animatronics should have the at the minimum the following two characteristics
   (a) It should have the face of the professor.
   (b) It should say at least one sentence (more is better) containing atleast 5 words in the professors voice.

   We will post office hours for all ME professors and we suggest that you visit the professor during their office hours to: (1) get a headshot for the animatronics face, and (2) record a video/sound track for your animatronics. All ME professors have been informed that student

group from the Mechatronics class will come to take a picture and record a sound track, so do not feel intimidated. If you have any questions/concerns talk with the instructor, Pranav Bhounsule. Also, sometimes high definition head shots are available in the ME website: http://engineering.utsa.edu/mechanical/faculty-staff/. **Be aware that all ME professors will be invited on Nov 30, 2018 to witness your creation.**

2. **Micro-controller:** The animatronics should use a single Arduino that is provided to you. We provided you with an Arduino MEGA.

3. **Sensors:** The animatronics should have a minimum of two (different) sensors that are used for the interaction. By different sensors it means that they should not be based on the same principle. For example, an ultrasonic sensor and infra black sensor use different wavelengths of light for range detection but they are both based on the same principle, that is a transmitter and a receiver, and using both of them counts as one sensor. However, using an ultrasonic or infra-black sensor with a camera is a permitted. Some other ideas are as follows (feel free to come up with you own ideas). Other sensor ideas are a microphone (be aware that it might be noisy around the atrium where grading will be done), color sensor, distance or range sensor, touch/contact sensor, light sensors (be aware that it may not be always possible to control the lighting in the room), motion sensors (e.g., gyroscope), direction sensor (e.g., accelerometer). Please talk with the TA/instructor if you need any clarifications.

4. **Actuators:** The animatronics should have a minimum of two moving parts.

   (a) It is mandatory to have a moving mouth in way that resembles a person talking. That is, it needs to be synchronized with the audio as much as possible.

   (b) The other moving parts can be any organ of your choice. Some examples are one or both ears, the nose, one or both eyes, eye brows, forehead. You can also be creative. For instance sunglasses that move up or down or moving headphones will count towards the second moving part. Please talk to the TA/instructor if you need any clarifications.

5. **Chassis/Supporting structure:** You are not allowed to use any animatronics kit. However, you can use construction set for the face (e.g., erector set). Other ideas are to use plywood, cardboard, plastic or anything that is easy to cut.

6. **Power:** The system may be tethered and thus powered by your computer. That is, the Arduino may be powered by a computer and/or battery. There are no restrictions on this aspect. However, note that if you are using certain motors, you might need to provide external power (not through the Arduino) to get enough torque out of the motors.

7. **Control/autonomy:** The animatronics should be autonomous. Once you start the program to run all interactions have to autonomous. No communication, physical or wireless, is permitted.

8. **Sound:** The animatronics should talk and the sound track should sync with the face movement. You may use a standalone microphone or your laptop speaker.

9. **Other rules:** The TA/instructor reserve the right to add additional/modify the rules as needed. Any change in technical specifications will be communicated through email via blackboard sent to the entire class.

10. **Interaction:** There will be a minimum of two interaction modes. In response to each interaction mode, the animatronics will move one or more joints. For example, (1) when the spectator waves their hand against an ultrasonic sensor, the animatronic's mouth might move and say a sentence, and (2) when the spectator touches a contact sensor, the animatronic's might move its eyebrow and speak out another sentence.

11. **Creativity:** Try to be creative. You could use this set up to build a fun interaction. For example, the animatronics tells a joke or plays a game of some sort. Try to keep the interaction for about 10-15 seconds atleast. Pre-program different simple behaviors (e.g., eyebrow moves different angles expressing different emotions or mouth opening different amounts) and use a random number generator to randomize the chosen behavior for different interactions.

4 Project report

Before you start the project, please go through the report template. This will be used for the milestones and constitutes a big chunk of your grade. The report template is posted here: http://aux.coe.utsa.edu/ pab/info/MechatronicsTemplate.docx. It is suggested that you go through the template and understand the requirement before you start working on the project. This way you will be better prepared for the hardware project and will know what things you would need to save (e.g., taking photos) as you do the hardware project. Please delete the items marked in RED in the template. These are only to help you write the report.

5 Weekly plan and milestones

Week 1 – Oct, 18/19: Download the report template: http://aux.coe.utsa.edu/ pab/info/MechatronicsTemplate.docx. **Milestone 1:** Search at least three animatronics designs on the internet and complete the write up Section 1: Literature review in the report template. Show it to the Teaching Assistant for a grade.

Week 2 – Oct, 25/26: Milestone 2: Brainstorm what your animatronics figure would do and then complete the write up in Section 2: Brainstorming (initial planning). Show it to the Teaching Assistant for a grade. **Please ensure that you order the components so that you are prepared for the next deadline for next week.**

Week 3 – Nov, 1/2: Milestone 3: Create the chassis/supporting structure including the joints (unpowered) and demonstrate that to the Teaching Assistant for a grade.

Week 4 – Nov, 8/9: Milestone 4: Program both the motors to response to the sensors and demonstrate that to the Teaching Assistant for a grade. Note that the motors/sensors need not be connected to the joints and chassis at this point.

Week 5 – Nov, 15/16: Milestone 5: Integrate the motors/sensors to the joints on the chassis and program the motors to response to the sensors but on the animatronics figure. Demonstrate that to the teaching assistant for a grade. At this point, you need not get the sound to sync and work with the animatronics. We are only looking for a rudimentary working version at this point.

Week 6 – Nov, 22/23: No lab, Thanksgiving holiday.

Week 7 – Nov, 30 (12 - 3 PM) demonstration: Ensure that the animatronics is ready for user interaction as specified in the technical specifications in the BSE Atrium. Make a YouTube video of your design and include that in the project report. Complete the Abstract, Sections 3 to Section 8, references, appendices. See the grading rubric below.

6 Grading (rubric):

Note that the hardware project constitutes 15% of your course grade but with restrictions. If your grand score normalized to 100 in the hardware project is greater than of equal to 50% then you are eligible for 15% course credit. However, if your normalized score is less than 50% then you are not eligible for any credit in the hardware project. This example illustrates the grading. If you normalized score is 80 out of 100, then your hardware project will contribute $0.15 \times 80 = 12$ points to your course score. However, if you normalized score is 49 or below then your hardware project will not contribute any points towards your course score.

The grading for the hardware project is as follows.

1. **(40 points)** Meeting milestones described in the schedule with point breakdown as follows
   (a) **(5 points each)** Milestones 1 needs to be met in Week 1 and Milestones 2 needs to be met in Week 2.
   (b) **(10 points each)** Milestones 3 can be met in Week 3 and Milestone 4 can be met in Week 4. Alternately, Milestone 4 can be met in week 3 and milestone 3 can be be met in Week 4. If both milestones are meet in week 4 then there will be a 5 point penalty.
   (c) **(10 points)** Milestone 5 needs to be met in Week 5.
   (d) We welcome completing the milestones ahead of time. For example, if you do Milestone 1 and 2 and show them to the teaching assistant in Week 1 then you can earn full credit for those two weeks and your group need not come to the lab on Week 2.
2. **(30 points)** Animatronics demonstration (everything works as given in the specification) on the day of grading. We suggest that you make and post a YouTube video (please reference it in the report) so that we can give you partial credit if your animatronics demonstration does not work during the grading period. The grading will take place from 12 PM - 3 PM in BSE Atrium (near Einstein's bagels) on level 1 in BSE).
   (a) **(10 points)** First interaction mode is working including mouth sync if applicable.
   (b) **(10 points)** Second interaction mode is working including mouth sync if applicable.
   (c) **(10 points)** Questions and answers between the instructor and/or teaching assistant.
   (d) All students in the group must be present during the demonstration. Please hand in the report to the instructor/teaching assistant if asked.
3. **(30 points)** Project report. Please follow guidelines in the project report template posted here: http://aux.coe.utsa.edu/ pab/info/MechatronicsTemplate.docx. The hard copy is due on grading day Nov 30, 2018 by 3 PM and soft copy to be mailed to the instructor pranav.bhounsule@utsa.edu by Dec 2, 2018 end of the day. Reports received after this date will receive no credit.

(a) **(5 points)** Cover page that includes the photo of your creation and a YouTube link to your animatronics video.

(b) **(5 points)** Abstract. Provide a succinct write up that describes you animatronics and what it does.

(c) **(10 points)** Section 3 Supporting Structure, Section 4 Joints and motors, and Section 5 Sensors.

(d) **(5 points)** Section 6 Programming for interaction

(e) **(5 points)** Section 7 Lesson Learnt and suggestions

(f) **(-3 points each)** If 1. Literature review, 2. Brainstorming, Section 8 Personnel, Section 8: Bill of materials, References are not included

7 Please read through these points in their entirety.

- Simplicity is the key to achieve a good score in the hardware project. It is more important that you meet the technical specifications rather than making a 'perfect' or 'sturdy' animatronics. Here are some suggestions:
  - Supporting structure: Cardboard or any easy to fabricate material for supporting structure is recommended. If your idea does not work, then you should be able to make changes quickly.
  - Joints: Minimize the moving joints. For example, you could do a mouth with two joints one for the upper jaw and one for the lower jaw. However, I recommend using only one joint (upper or lower), this will meet the specification.
  - Motors: Servos are easiest to interface. Stepper motors give more precise movement but not required. DC motors are good for continuous movement (e.g., speed control).
  - Sensors: Some suggested sensors, which tend to be robust to light and ambient conditions are described. Contact sensors (e.g., could mount on the nose or cheek), range sensors such ultrasonic/infra-black (e.g., could mount these near the eye or between eyebrows or above mouth), gyroscope/accelerometer (e.g., could mount it on the a pinned nose so twisting the nose is used for interaction).

- Work ahead of schedule. Milestones 1 and 2 are easy and should take 2-3 hours at most. But Milestones 3, 4, and 5 are harder and each may take a good 10 hours, including the need to buy parts.

- Expect failures. Failures may include burnt motors, failed sensors, failed/broken support structure, need to buy sensors/motors, ideas not working as planned. Failure is expected and thats why you should aim on completing Milestones 3, 4 and 5 early.

- Please respect the people who will be represented in the animatronics figures. In representing the animatronics figure, you will not use foul language, imagery, gestures that are discriminating and/or insulting. If you are in doubt, please consult with the teaching assistant and instructor. In addition, please read through UTSA policies on Nondiscrimination on this link: http://www.utsa.edu/hop/chapter9/9-1.html.

- All ME professors will be invited to see their animatronics on Nov 30, 2018.
- The professor will be randomly assigned by a computer program.
- The students will work in groups of 2 or 3.
- Your device should work when the instructor and/or teaching assistant comes to grade at your table.
- Ready-to-use kits are not allowed and will lead to zero points in the lab. However, you may use construction set such as erector set for the frame if desired.
- Salvaged parts/3-D printed parts, motors/sensors from friends/salvaged ones are highly recommended to save costs.
- Students will get reimbursed $30 per student (e.g., groups of 2 will get reimbursed up to $60 and groups 3 will get reimbursed up to $90). You can only get reimbursed by submitting itemized receipts. Please save receipts, you should also take a photo of the receipts, just in case. The University cannot pay out money paid in taxes. To get tax exemption please give the following form to the vendor:
  http://aux.coe.utsa.edu/ pab/info/TaxExemptForm.pdf. The form for reimbursement is here:
  http://aux.coe.utsa.edu/ pab/info/Student_Petty_Cash.pdf. The form should be submitted to Cayla Jimenez in the Mechanical Engineering Office (3rd floor Engineering building).
- Here are some useful websites where you can find electronics for this project
  (1) https://www.sparkfun.com,
  (2) http://www.adafruit.com/,
  (3) http://www.adafruit.com/,
  (4) http://ebay.com/ (Be mindful of shipping times).
- Electronics bought online are usually much cheaper but there are two issues with buying stuff online; (i) it takes time for stuff to arrive, and (ii) the cost of shipping can be significant. Hence it is recommend that you also keep in mind that there are local stores that you can go to, especially if you are in a rush. Here are two sources:
  (1) Radioshack (http://www.radioshack.com/) and
  (2) Intertex Electronics (http://www.intertexelectronics.com/) They have a great choices and are relatively inexpensive. They are located at: 1200 W Hildebrand Ave, San Antonio, TX 78201 (sometimes picky about accepting tax exemption form but otherwise great.)
- You will see that there are multiple website/stores that offer similar products but at different price tags. How do you decide which one to go for? Here are some factor that might help you to decide.

  1. Is the component (e.g. sensor) plug and play or needs additional wiring (e.g. soldering transistors or adding capacitors and/or resistors).
  2. Is there readily available code for the component to enable ease of interfacing?
  3. Is the component compatible with the hardware you have?
  4. Have other people succeeded in using the component in their project?

5. Does the cost fit your budget?
6. Does the component specification meet you needs? For example, does the range sensor have adequate range?

All said, I can guarantee that you will make mistakes. For example, buying the wrong sensor. The key is to make mistakes early, so that you have time to rectify them.

8 Returning the parts boxes/arduino

After the end of the grading on November 30, 2018, you will return the all mechatronics supplies that were given (excludes the parts you bought for hardware project) in BSE 2.216. An equipment return sheet will need to be signed by one group member.