

# ME 511 Mechatronics @ UIC

## Project: Interactive Animatronics

The project should be done in a group of two unless noted otherwise in this document.

Pooling of kits is encouraged

Updates are in magenta.

## 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. The student should (ideally) pick up a known 'news-worthy' personality (e.g., actress, actor, sports personality, politician). It is highly recommended that the student customize the animatronic to add humor (e.g., change the voice, distort the face, move face parts like the nose, ears, hair, mouth, tongue, teeth, etc in exaggerated fashion, interact in a funny way). But the interaction should not use foul language, imagery, gestures that are discriminating and/or insulting.

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 design and 3D print.
6. 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 well known celebrity 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 celebrity such as "I'll be back..." (Arnold Schwarzenegger in the Terminator 2: Judgement Day) or set up a conversation such as Q&A in a funny way.

The technical specifications for the animatronics are as follows.

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

Remember that you will display the animatronics face to the public during the last week of the semester.

2. **Micro-controller:** The animatronics should use a maximum of two Arduino UNOs. Each student has one Arduino from the kit they used for the course.
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 red 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-red 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 and customize.
6. **3D printing:** There should be atleast one 3D printed part that is needed for the animatronics to work. Some examples include, joints, connectors between motor and the face parts.
7. **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.
8. **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.

9. **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.
10. **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.
11. **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.
12. **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. Another idea is to 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 as an instructable

The project report will be an instructable that you will post for public consumption. It should be publicly accessible. The goal is two-fold: one, to document your work, and two, to inform other viewers who would like to use your instructions to create their own. Bonus: You can use the instructable for marketing yourself on your job hunt.

Use the website, <https://www.instructables.com/> to post the instructable. You will have to either create an account or use an existing account (e.g., google) to sign up. Share the link of your instructable with the instructor, pranav@uic.edu by **(Fri) May, 5 2023**.

When you submit the instructable please include these things in the appropriate place

1. **Project title** Keep it short but make it informative. For example, Animatronics face of Obama or ObamaBot—an animatronics face.
2. **Category** use circuits. **Channels** use Arduino
3. **Introduction** Using 4-5 sentences explain what the animatronics does and give a summary of supplies used
4. **Supplies** Should contain an itemized list of supplies used. It might be best to include a table with the following columns. “Description” (e.g., Arduino UNO rev 3), “Quantity”, “Unit price”, “Total price”. For some items such as cardboard which were obtained from scrap can be listed as such without a price tag.
5. **Steps.** Divide the entire work into units which will be communicated as steps. Write detailed steps on how to build the animatronics face. Please add figures/videos as needed at each step. It is important that you take pictures/video of the animatronics as you build it to ensure that you are able to convey what you created. Here are some things that need to be addressed

- Supporting structure
- Joint design
- Actuators
- Sensors
- Programming. Limit yourself to the algorithm used for the code. Dont copy paste code into the instructable. Feel free to upload code as needed.
- The final product. Include a photo and a video (ideally linked through YouTube) of your creating.
- Lessons learnt and suggestions for improvement: List 2-3 lessons learnt including mistakes you made. Give 2-3 suggestions on how one can improve the animatronics face.

## 5 Weekly plan and milestones

**Week 1 – March, 13/14: Milestone 1:** Search at least three animatronics designs on the internet and submit your write up on gradescope. Read the report Sec. 4 carefully and start thinking of Milestone 2 as it is a major milestone. Due on Fri, March 17, 2023. This is an individual milestone.

**Week of March, 20/21:** No lab, Spring break.

**Week 2 – March, 28/29: Milestone 2:** Brainstorm on your animatronics and create a presentation to discuss your ideas with the instructor/TA.

1. Which animatronics celebrity will you create?
2. What is type of interaction that will take place? What is the animatronics will say? How will you obtain/create the sound track?
3. Which parts of the animatronics will move (joints)? How will they move (which motors)? What is the stimulus (which sensors)? How will you fabricate the structure/chassis?
4. How will you overlay the face on the supporting structure?
5. How will you power the Arduino, motors, sensors? Do you have enough pins? Would you need to two Arduinos? If you would use 2 Arduinos how will you sync them?
6. What are the sensors/motors/other electronics available to you and which items need to be bought?

Please sign up for a 15-min slot using this link <https://tinyurl.com/y3h7h6ac>. **There will be sign up slots for March 30 and March 31st, you should be able to sign up mid-week.** Be ready with your presentation during your slot. Your presentation should address the questions above. Both team members should be present. The zoom link is here: [tiny.cc/uiczoom](https://tiny.cc/uiczoom). Please wait in the room, dont sign out if you are not in immediately. The instructor/TA might be busy with the another group. Once your animatronics idea is approved, please go ahead and order supplies. **Please ensure that you order the other components so that you have all items needed in the next two weeks.**

**Week 3 – April 4/5: Milestone 3:** Create the chassis/supporting structure including the joints (unpowered) and demonstrate it to the Teaching Assistant for a grade. *Important: Be sure to take photos/videos/document your work for use in the instructable (see Sec. 4 for more details).*

**Week 4 – April 10/11: 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. *Important: Be sure to take photos/videos/document your work for use in the instructable (see Sec. 4 for more details).*

**Week 5 – April 17/18: Milestone 5:** Integrate the motors/sensors to the joints on the chassis and program the motors to response to the sensors, but now placed and secured 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. *Important: Be sure to take photos/videos/document your work for use in the instructable (see Sec. 4 for more details).*

**Week 6 – April 27 (2 to 3:15 PM) Demonstration:** Ensure that the animatronics is ready for user interaction as specified in the technical specifications in the MIE atrium (ERF second floor near MIE faculty offices).

**Week 7 – May 5th (Fri) Report:** The final report should be submitted as an instructable (see Sec. 4 for more details). Ensure that your names are on the instructable. Please send a link to pranav@uic.edu.

## 6 Grading (rubric):

The grading for the hardware project is as follows.

1. **(40 points)** Meeting milestones described in the schedule with point breakdown as follows
  - (a) **(5×2=10 points)** Milestones 1 needs to be met in Week 1 and Milestones 2 needs to be met in Week 2.
  - (b) **(10×2=20 points)** 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 instructable) 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 2 to 3:15 PM on April 27 in the MIE atrium (ERF 2nd floor near MIE faculty offices).

- (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 based on specs mentioned in this document (e.g., on sensors used, 3D printed part)
3. **(30 points)** Project report as an instructable. Please follow guidelines shown in Sec. 4 for more details. Submit the link to the instructor via email, pranav@uic.edu. The deadline is **Friday May 5th**. Please send a link to your instructable. Reports received after this date will receive no credit. The 2 items, literature review (week 1) and brainstorming (week 2) should NOT be in your instructable. These will be graded separately as part of your Milestone 1 and 2.

## 7 Please read through these points in their entirety.

- Before you buy sensors/motors for the project be mindful that you have sensors/motors in your Elegoo kit that you can use for the project. You should be able to pool your kits to double the number of electronics that you can use. Here is a list of Elegoo items that have a high potential to be useful

**Sensors:** Tilt Ball switch (measure angle of tilt), Joystick/Remote (remote control), Ultrasonic sensor (distance of an object), Photoresistor/Photocell (measure light intensity).

**Motors:** Stepper (moves a few degrees at a time), Servo (controlled to a given position), DC motor (control the speed), Buzzer (make sound, not for creating soundtrack)

- 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-red (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 that's why you should aim on completing Milestones 3, 4 and 5 early.
- 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.
- 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.
- 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.amazon.com/>,
  - (4) <http://ebay.com/> (Be mindful of shipping times).
- 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 factors 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. Are 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 your needs? For example, does the range sensor have adequate range?

As you build the animatronics face, it is highly likely 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.

- I will be providing each group with an MP3 player, a speaker, and a MicroSD card. This is yours to keep.
  1. [MicroSD card, 16 GB](#)
  2. [DFPlayer mini MP3 player module](#)
  3. [Speaker, 5 W](#)

Here are instructions on connecting and playing a recording  
[https://wiki.dfrobot.com/DFPlayer\\_Mini\\_SKU\\_DFR0299](https://wiki.dfrobot.com/DFPlayer_Mini_SKU_DFR0299).