ME 218a Fall 2022: The Freaked-out FLIER's Friend
A Personal Animatronic Lifeform

Grading Session on November 30 from 1-5 pm.
Project Presentation on November 30 starting at 7:00 pm.

Goal:

The goal of this project is to provide a framework in which you can apply your knowledge of microcontrollers to provide an enjoyable experience for users and observers.

Purpose:

The underlying purpose of this project is to give you some experience building an electromechanical widget. We expect that this will involve working with sensors, driving actuators, designing event-driven software, and implementing that software in C on a PIC32 microcontroller. We expect to see all of these elements in every solution. Your lab kit contains sensors and several kinds of display, although you are not limited to using only these. You are limited to an expenditure of **$120.00 / team** for all materials and parts used in the construction of your project. Materials from the lab kit, the Cabinet of Freedom and any consumable supplies do not count against the limit; all other items count at their Market Value.

Background:

Breaking news! studies have shown airline fliers experience sky high levels of stress associated with flying. Your startup PALco, has decided to jump on this market by providing a calming companion. Your team has been tasked with designing a Personal Animatronic Lifeform (PAL) to meet this need. The PAL should provide therapeutic support to the flyer to calm their nerves. Your PAL needs to be ready before the first trial flight (on November 30).

The Task:

Your PALs will be tested on an EdCarryAir flight from SPDL to DSC (that is, distributed around the Atrium of Bldg. 550 (our classroom building)). There they will be presented to the FLiers Interested in Experiencing Relaxation (FLIERs). The FLIERs will wander around the cabin interacting with the PALs[1] and trying to "sit back, relax and enjoy the flight". You should strive to make your PAL calming, interactive, durable, educational, and electromechanical.

Hey doctor, sometimes I get nervous on airplanes

John Mulaney

Specifications

PAL Operation:

- ☐ The PALs will power up into a welcoming mode, offering FLIERs the opportunity to interact with your PAL. Whenever it is in this mode it should inspire a sense of calm in the FLIERs.
- ☐ Since science has determined that it takes about a minute to achieve a state of Zen, it should take the average FLIER approximately 60 seconds to interact with your PAL. No one not already in a state of Zen should be able to completely master your PAL in less than 30 seconds.
- ☐ To provide the FLIER with a sense of progress toward the Zen state, each PAL should include a creative display of the passage of the time since the FLIERs have started using the PAL. **7-segment displays don't count.**
- ☐ To avoid annoying your seatmates, your PAL must only operate when in active use by FLIERs. The PAL should reset to the welcoming mode within 30 seconds after the FLIER stops interacting with the PAL.
- ☐ To allow your PAL to feel life-like it should involve at least 3 distinct FLIER interactions and PAL expressions.

[1] Remember that this is an acronym. *The New York Times* has addressed this in the past. This is how you pluralize an acronym.

- ☐ Your PAL should require large scale motion on the part of the FLIER for at least one of its interactions.
- ☐ When the PAL determines that the FLIER has achieved a Zen state, it should provide a clear audio and/or visual indication of Nirvana. This indication may last no more than 30 seconds before the PAL resets.
- ☐ The PAL should be usable without the guidance of a crewmate. To accommodate international fliers, any static instructions must be only in pictorial form (Think IKEA[2] instructions).

Basic Specifications:

- ☐ A team of three class members will construct a PAL.
- ☐ The PAL must have parts that visibly move under the control of the PIC32 .
- ☐ While it is permissible to use consumer devices as components in a PAL, PALCo requires, in order to avoid IP issues, that such devices must be substantially modified before being incorporated into your project. We don't want you to just buy significant portions of your project. If there is any question as to whether or not the purchased component has been modified significantly enough, please see the teaching staff.
- ☐ Each PAL must respond to at least three distinct FLIER inputs/interactions.
- ☐ At least one of the user interactions must be interpreted as an analog input to the PIC32 from the user. The analog input must be used to produce some behavior by the PAL that makes use of the analog nature of the input. No simple thresholds.
- ☐ In addition to the analog input, at least one of the user interactions must involve non-contact sensing.
- ☐ Each PAL must provide the user with feedback about his/her actions. The feedback can take the form of an expression or gesture that the PAL displays. The feedback must include at least one of: haptic/audio/tactile feedback. Multiple modes of feedback, including modes not listed here, are encouraged.
- ☐ The complete PAL must be a self contained entity, capable of meeting all specifications while connected only to the provided project power supply.
- ☐ In order to meet airline carry-on requirements, all components of the PAL **MUST** fit into a total volume no more than 50 cm wide by 50 cm deep by 100 cm high. During operation, the PAL should not require user input from more than 75 cm away from any part of the PAL. Two teams' PALs must both be usable while sitting together on one of the 1.5 m wide tables in our classroom. The entire PAL must be easily and safely moved from the SPDL to the grading session and then to the test flight (i.e., to the Atrium) for evaluation. Make sure that you plan for this.
- ☐ The emphasis in the project is on robust electronics, software and mechanical systems built with real craftsmanship. Paint alone does not add to either functionality or craftsmanship. This is not to say that you may not decorate the machine, but simply that it should not become a focus. Any painting that is done near the SPDL must be done using appropriate masking so that no paint residue is left on the building, furniture, sidewalk, driveways, grass, or trees. No painting in the SPDL! And no glitter!
- ☐ While it is normally not a good practice, the finished circuitry may be constructed on your solderless bread-boards. This has been done to allow you the maximum time to spend on your project, without having to learn electronic prototyping techniques as well. Be sure to secure the bread-board and connections so that they will not be disturbed during turbulence, take-off, landing or the moving process.
- ☐ Accurate schematics and state diagrams are such a useful aid in debugging that you should be prepared to show your up-to-date schematic or state diagram to any coach or TA whenever you ask them for help on your project.

Safety & Hygiene:

- ☐ The PALs must be safe for both users and spectators.

[2] Intragalactic Knowledge Enforcement Agency

- ☐ No glitter!
- ☐ Be considerate of your neighbors in the lab when debugging any audio output; use headphones.
- ☐ There is a strict ban on toxic materials. This prohibition includes Volatile Organic Compounds (VOCs) (i.e. hydrocarbon based spray paints or other noxious fumes). This prohibition also includes while you are working on the PAL in the SPDL.
- ☐ No painting in the SPDL (or anything attached to the SPDL).
- ☐ No part of the PALs may become ballistic unless completely constrained within the PAL.
- ☐ No pyrotechnics or fire of any kind! Be advised that smoke contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm[3].
- ☐ If the PALs contain any liquids, they may not be conductive (with the exception of water) or corrosive, and **MUST** be packaged in a fail-safe manner while always being shaken, not stirred.
- ☐ The use of gremlins in you project is ferby-dden.

Checkpoints

Design Review:

During the day on **November 7** in room 162 of the Peterson building (our classroom building) we will conduct design reviews. Signups for the hour-long slots for 3 teams will happen via a Google Sheet. Each group should prepare a few **simple** PowerPoint slides (scans of sketches are OK). **No code, no state diagrams, no circuits.** The slides should show your concepts, a preliminary event list with responses, and a list of **how you are going to meet the user interface requirements** along with the feedback from the meeting with your coach. One member of the team must bring a laptop and any necessary adapters to produce a VGA or HDMI video signal to connect to the screen for your presentation. You will present these to other members of the class, members of the teaching staff and coaches (crewmates) so that all may hear about your ideas and provide feedback and advice. At this time you will be required to identify the core functionality of your proposed design and how it meets the interaction requirements.

Animals are such agreeable friends - they ask no questions; they pass no criticisms.

George Eliot

First Checkpoint:

On or before **11/11/22**, you must submit a schematic of at least the core functionality initially identified on 11/7/22 and a refined set of events with details on the responses. Modifications to the core functionality may take place up to this point. A KiCad schematic within a word document describing your core functionality should be uploaded to Gradescope. Only one team member needs to submit your checkpoint documentation.

Dogs are the leaders of the planet. If you see two life forms, one of them's making a poop, the other one's carrying it for him, who would you assume is in charge.

Jerry Seinfeld

Second Checkpoint:

On or before **11/17/22** you will be required to demonstrate a minimal level of function:

- The hardware & software necessary to do each of the following:
  - sense inputs (at least 3 user inputs)
  - make decisions (state machine with at least 3 states driven by keyboard input)
  - implement electromechanical actuation and user feedback
- Submission of a KiCad schematic of your circuit will also be required.

It is possible to fly without motors, but not without knowledge and skill.

Wilbur Wright

[3] Proposition 65, California Health and Safety Code §25249.6 et seq.

Third Checkpoint:

On **11/29/21** you will be required to demonstrate integrated functionality of all sensing inputs, plus software and timing, plus activating all actuators that will be required. In other words, everything should be complete with the exception of improvements in user experience and fit, finish, and appearance.

Rumack: Can you fly this plane, and land it?
Ted Striker: Surely you can't be serious
Rumack: I am serious... and don't call me Shirley

Airplane!

Grading Session:

On **11/30/22** from **1:00 pm to 5:00 pm** you will be required to demonstrate your fully integrated and finished machine.

Watching one-winged ducks.
Circling above my head.
Do not travel far.

Lawrence Domingo

Public Presentation:

This will take place on **11/30/22** starting at **7:00 pm** in the Atrium of Building 550. At this event, members of the public will be encouraged to act as FLIERs, and will interact with your PALs.

Animals can inspire us to be less busy, more present, less worried, more joyful, and more passionate about life. They will never judge us for the things we do or don't do.

Kristen Moeller

Report:

Draft due on **12/5/22** by 4:00 pm. The final version (with revisions incorporated) is due by 5:00 pm on **12/9/22**.

The secret to sloths' extraordinary endurance is their lethargic nature. They are paragons of low-energy living, with a suite of ingenious, energy-saving adaptations honed over many millennia and worthy of the most eccentric and gifted inventor.

Lucy Cooke

Evaluation

Performance Testing Procedures:

All PALs will be tested by a demonstration, performed by a team member, that should show all of the possible user interactions.

Grading Session Presentation:

Each team should prepare a 30 second (no more) presentation to introduce their PAL. This presentation should highlight the unique features of the design, **not the circuit or software details.** As an example, think back to the xylophone descriptions that were played on the first day of class. You will be setting up your PAL, one at a time, and delivering your presentation in room 202 Thornton between 1:00 pm & 5:00 pm on the day of the presentations. During this time each team and their PAL will be photographed. Starting at 5:00 pm you will move your PAL into the Atrium for the public presentation, which will begin at 7:00 pm.

Grading Criteria:

- ☐ **Concept (20 %)** This will be based on the technical merit of the design and coding for the PAL. Included in this grade will be evaluation of the appropriateness of the solution, as well as innovative hardware, software and use of physical principles in the solution.
- ☐ **Implementation (20 %)** This will be based on the prototype displayed at the evaluation session. Included in this grade will be evaluation of the physical appearance of the prototype and quality of construction. We will concentrate heavily on craftsmanship and finished appearance.

- ☐ **Performance (40 %)** Half of this (20 %) will be based on the results of the checkpoints, the other half will be based on the results of the performance testing during the evaluation session. Full performance credit will be given only if the machine works on the first attempt during the grading session. Performance will be judged first on the ability to demonstrate the core functionality and second on any embellishments to the core functionality. **To earn the performance points, you must demonstrate at least the core functionality.**
- ☐ **Report (10 %)** Preliminary project reports are due **December 5, 2022** at 4:00 pm. The report should be in the form of a stand-alone web site and must include schematics, pseudo-code, header & code listings, dimensioned sketches/drawings showing relative scale, a complete Bill-of-Materials (BOM) for the project as well as a 1 page description of function and a "Gems of Wisdom for future generations of 218ers" page. The actual website must be hosted and you must **submit the URL to your site in the specified spreadsheet**. It is critical that the URL to your report be in the spreadsheet on time so that the peer reviewing team will have an adequate opportunity to review it before class the following day. Final versions of the reports, incorporating the review comments are due by 5:00 pm on 12/9/22.
- ☐ **Report Review (10 %)** These points will be awarded based on the thoroughness of your review of your partner team's report. Read the explanations, do they make sense? Review the circuits, do they look like they should work? Could this PAL realistically be built for $120? If, during grading, we find things that don't make sense or circuits that won't work we will consult your review. If the review caught them, then the team will lose points on their report. If the reviewers missed it, then they will lose points for their review. The report review should be submitted on Gradescope by 4:00 pm on 12/6/22.

Suggestions

We understand that the project definition is probably a bit more open than you might be used to. To help you get your creative juices flowing we offer some reflections that you might want to consider.

- ☐ Don't just think buttons. Think about novel ways to sense an action and give feedback. Remember, you have more than just fingers available to actuate and you are mechanical engineers (at least most of you). Think fun linkages!

> *We made the buttons on the screen look so good you'll want to lick them.*
>
> *Steve Jobs*

- ☐ **The Tao of 218:** Simplicity Leads to Reliability. Remember, 7 of our years is one PAL year , but you have only 456 hours available to complete the project (and tend to the other things in your life) before it is due.
- ☐ Consider your person-power. If you reference the ME218 Archive (me218archive.stanford.edu), be sure to note that most of the ME218a projects there were completed by a team of 4 and you only have a team of 3. We will be taking that into account. Be sure that you do too.

Exercise your creativity:

We encourage, and hope to foster, a wide range of solutions to the problem. This will make for the most enjoyable presentation for your audience. There is no "best" way to solve this problem (or best problem to solve), so don't spend time looking for it. While brainstorming, you might want to review the history of animatronics, Tamagochi, Aibo, Disney and robotic expression for inspiration.

Remember that we interact with electronic devices every day. People tend to have more fun with projects that don't try to emulate the look and feel of actual products. ME218 is an opportunity to design things that are **fun** and **whimsical**. Take advantage of that.

Make your project robust:

Your machine must be rugged enough to survive your testing as well as "testing" by the audience. Don't be timid about playing with your project before the presentation. Play with it as if you didn't know its weaknesses. Let your friends play with it. Find out if it can survive people playing with it before the presentation.

While the emphasis in the lecture has concentrated on the electronics and software, don't forget the mechanical aspect. Historically, ME218a project failures are often due to poor mechanical design or implementation. Pay attention to craftsmanship. It will pay dividends in many ways.

Resources

Websites:

SparkFun (www.sparkfun.com)
Mouser (www.mouser.com)
Adafruit (www.adafruit.com)
McMaster-Carr (www.mcmaster.com)
Seeed Studio (www.seeedstudio.com)
ServoCity (www.servocity.com)
Hackaday (www.hackaday.com)
HobbyKing (www.hobbyking.com)
Jameco (www.jameco.com)
Ponoko (www.ponoko.com)
DigiKey (www.digikey.com)
Newark (www.newark.com)

Local Stores:

Anchor Electronics in Santa Clara
Jameco in Belmont
Sheldon's Hobbies in San Jose
TAP Plastics in San Mateo

Gems of Wisdom:

Be sure to check out The ME218 Archive (me218archive.stanford.edu) for guidance from past generations.