Supplementary Materials Table of Contents

1. Appendix A: Scripts and Questionnaires

1.1 Interview Script Administered to 8 Subject Matter Experts

Interview script with AI/ML Professional:

Introduction:

Hello, we are a team of WPI students working with the CPSC. Our project involves AI and machine learning in consumer products, and we would like to ask you a few questions about AI/ML. This will be an anonymous survey, so your name will not be revealed. Do we have your permission to record this interview for our own reference? This recording will not be published. You do not need to answer questions if you do not want to, and you can leave the interview at any time.

- What is your experience working with AI/ML?
- How would you define Artificial Intelligence?
- How would you define Machine Learning?
- What separates an AI product from an ML product?
- What are some of the primary components of an AI or ML system?
    - Functions?
    - Capabilities?
- How do you go about identifying whether a system uses AI or ML?
    - What is the first thing you look for?
- Can you think of any physical hazards that could be caused by the use of AI or ML in a product?
    - Physical hazards are threats to the safety of users (e.g. chemical exposure, fire, electric shock) This project is not concerned with security hazards or privacy.

1.2 Interview Script Administered to 10 Employees

Interview script with CPSC employee:

Introduction:

Hello, we are a team of WPI students working with the CPSC. Our project involves AI and machine learning in consumer products, and we would like to ask you a few questions about how the CPSC might handle these types of products. This will be an anonymous survey, so your name will not be revealed. Do we have your permission to record this interview for our own reference? This recording will not be published. You do not need to answer questions if you do not want to, and you can leave the interview at any time.

- What is your position in the agency? What does the job involve? What products do you work on?
- What are common safety issues that you come across in your program area?
- How does your program area in the CPSC measure physical risk/hazards?

- How does your program area in the CPSC proceed once a product is identified as hazardous?
- Are you familiar with AI and ML technology?
- Can you see AI or ML making its way into your field and if so how do you imagine that happening?
- Do you see any potential safety issues that could be caused by the AI/ML in a product?

1.3 CPSC Questionnaire With 34 Respondents

We are a team of engineering students from Worcester Polytechnic Institute working with the CPSC on artificial intelligence (AI) and machine learning (ML) in consumer products. Our goal is to help the CPSC determine whether a product that is being investigated could potentially incorporate AI/ML technology. This assessment will ultimately lead to addressing the physical hazards of AI/ML in consumer products. This anonymous questionnaire will give us background information that we can use to further assist the CPSC. Thank you in advance for your time.

1. What is your position in the agency? What does the job involve? What products do you work on?

2. What are common safety issues that you come across in your program area?

   Artificial Intelligence (AI):
   Artificial intelligence is a field of computer science that allows a system to simulate human capabilities by interacting with its environment in an intelligent manner.

   Machine Learning (ML):
   Machine learning is used to train AI and involves algorithms that allow a machine to learn from given data and improve over time.

3. Can you see AI or ML making its way into your program area? If so, how do you imagine that happening?

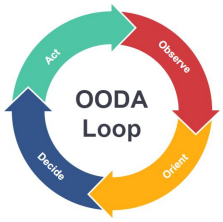
4. Do you see any potential physical safety issues that could be caused by the AI/ML in a product?

2. Appendix B: Interview Reports

2.1 AI/ML SME Interview Report

Industry Subject Matter Experts

October 22, 2020: AI and ML expert working in government



- AI is difficult to define but works similar to the ACEEE and OODA loop
- ML is an algorithm to train AI that consists of both supervised and unsupervised learning
- Components consist of Sensors, Algorithm, and processing unit, with a training component for ML
- AI can be used in a support role or in a systems role.

October 30, 2020: Presidential Innovation Fellow who has done significant work on AI ethics

- AI is the idea of simulating human capabilities and is within the category of data science
- ML is a subset of AI that is a series of advanced algorithms for supervised and unsupervised learning processes; the intersection of AI and analytics
- Must have power, sensors that collect data, computing, and hardware/software

November 4, 2020: Developer of Gov Systems, GSA Deputy Software Category Manager

- AI is a “Catch-All” Phrase
- AI is not AI without human intelligence supporting it
- Machine Learning “uses algorithms to create epochs,” under the umbrella of AI
- Must use process flow, a User Interface system, Surface Oriented Architecture
- Found using IT assets, hardware assessments, and reading the software

November 6, 2020: Expert in business applications of AI

- Many Subfields under AI: Robotics, Natural Speech/Learning, Machine Learning
- Machine Learning is a sub-field of AI
    - An algorithm that can search vast quantities of data to predict or classify an output
- AI and ML differ the same as a physician and a neurologist
- An easy way to identify AI/ML is to see if a device is making predictions over time, looking at physical actions over the components involved

- Consider what the consumer may see vs what the manufacturer knows. See if it remembers and reacts based on previous actions

November 6, 2020: Works on medical devices and using AI to make predictions in the medical field

- ML uses statistical methods to analyze data where it creates a model and keeps getting new information to analyze
- AI is built around developing rules, ML is about looking at actual data
- ML can involve analysis and AI can include modeling
- Doesn't necessarily have to learn as it's used, may have learned in the past

November 12, 2020: Follow up interview with AI and ML expert working in government

- CPUs: take inputs, find facts and based on the data given, and provides a concise answer
    - Little can be done without known data
- Sensors: real time data sources, no need to worry about when the data was taken
- Memory processors such as a USB stick do not count as AI
- Algorithms: Comparative data analysis against one another, identifying differences
    - Models to understand the difference
    - If it's trying to compare and find differences, it's an ML algorithm
- AI is direct analysis, ML is comparative analysis
- Random Number Generation: Not perfect. True RNG systems will be perfectly random unless they are tied to random events
- Machine Learning:
    - Monitor: What do I have here, and how do they relate to other samples?
    - Measuring: How are they similar, how are they different

iRobot Mechanical Design Employee

- November 12, 2020
- Primarily working on the Roomba
- Works closely with software teams
- Numerous amount of testing before the product is released
- Various amounts of AI functions in the Roomba
    - Sensors are a component that can make up an AI system
    - Roomba can map where it is in the room

Conclusions of the Research Team:

- AI is difficult to define, but it involves a machine interacting with its environment in an intelligent manner
- Many would consider ML a part of AI, and an ML system can take in data and learn from experience

- One of the main differences between AI and ML is that AI is the analysis, while ML is the process of modeling
- Some of the primary components of an AI/ML system include sensors and a processor
- AI systems are intended to solve difficult problems, and an ML system requires a mechanism to be trained
- Physical safety hazards could be caused by failures in the AI/ML system

Academic Professionals:

October 26, 2020: computer science professor, works on machine learning in medical and facial recognition

- Machine Learning: a system created by teaching a machine how to act or how to see from many examples of how to do so correctly

October 27, 2020: computer science professor, works on biology and medicine focus on machine learning

- AI is defined as the field that deals with writing computer programs that gain intelligence
- Machine Learning: able to learn from experience, improves over time
    - Includes machine vision and natural language processing

Conclusions of the Research Team:

- AI is the field of writing programs that allow a device to become intelligent, or resemble human decision-making
- ML teaching a machine by feeding it data and allowing it to learn from experience and improve over time
- Machine vision and natural language processing are common uses of ML

Comparisons Drawn by the Research Team:

- Nearly all interviewees stated that AI is related to human intelligence, saying that human intelligence is necessary for AI or AI resembles human intelligence
- Academics gave more clear definitions of AI/ML, while industry SMEs stated that it is difficult to define
- SMEs were better able to discuss components of an AI/ML system and potential hazards or sources of error

2.2 CPSC Employees Interview Report

Electrical Engineering

Electrical Engineering Employee

- November 3, 2020
- Electrical Engineering Division Director
- Products involved
    - Most electronics
    - Not typically many electronics, but more focus on voluntary and mandatory standards
- Primary Hazards
    - Electric shocks and fires
- CPSC utilizes Data Sheets to identify issues
    - CPSR: Risk systems
    - Fast Tracking system to asses products
- Potential AI/ML Hazards depend on the size of the project area, and the product examined.

Engineering Division Employee

- November 4, 2020
- Mechanical hazards are the most common
- Products involved
    - ROV, standards development
- Identify issues by looking for injuries
- Information is mostly gathered through reverse engineering
    - More can be gathered if needed but can be difficult
- Software issues are mostly identified through system failures

Electrical engineering employee

- November 9, 2020
- Products involved
    - Connected products and self balancing scooters
- Primary hazards
    - Shock and fire hazard
- CPSC looks to failure patterns to identify issues with software
- Potential hazards
    - Turned on in the middle of the night on its own
    - Did not cause any problems but there is a threat of danger.
- Software would be hard to look into and would have to be identified through failure patterns

Electrical Engineering Employee

- November 12, 2020

- 3D printers and printed products, IoT, VR, nanomaterials
- Hazards are identified by looking at failure patterns
- Important to consider the functions and exposure involved with the product
    - Types of exposure could include heat, light, or sound
- Electronic products are becoming closer to the human body, a source of potential hazards
    - Fitbit was recalled due to skin irritation

Electrical Engineering Employee
- November 12, 2020
- Works with light electric vehicles (LEVs)
- Fire and shock hazards
    - LEVs contain lithium ion battery packs
- Software monitors system parameters that could impact consumer safety
- Combining products could lead to additional hazards, such as using a VR headset while on a hoverboard

Conclusions of the Research Team:
- The CPSC electrical program area focuses on a large range of sources
    - IOT, Mobility devices, ROV, electronic devices
- Most common hazards
    - Fire, shock, mechanical hazards
- Potential hazards
    - Oven that turns on automatically
- Combining products could lead to additional hazards, such as using a VR headset while on a hoverboard

<u>Fire Program Area</u>
Fire Protection Employee
- November 3, 2020
- Fire Program Area team
- Products involved
    - Cigarette lighters, cooking equipment, floor/wall covering, furniture
- Report is provided annually about most recent fire loss data
    - 3 to 5 year focus
    - Examine ignitions, materials first ignited, fire protection equipment
- CPSC can collect samples when testing a product either from the consumer or purchase it
    - Able to request information such as engineering drawings and sometimes software when opening an investigation
- AI physical safety hazard - App controlled toasted oven turned itself on

Fire Protection Employee

- November 9, 2020
- Products involved
    - Gas Grills, flammable refrigerant, flammable liquid containers
- Can request information from manufacturers
    - Did not test software, mostly mechanical
    - Would have access to drawings, procedures, manufacturing process
- Potential AI/ML
    - Gas grills - temperature probes that cook the meat a specific way
    - Smart oven - probes and a controller that is controlling the heat and other aspects to get to the desirable state
    - Thermostats - uses AI and potentially ML
- Safety hazards of AI/ML
    - Promotes unattended cooking
        - But easier for consumers

Conclusions of the Research Team:

- The CPSC fire program area focuses on ignition sources
- They can request information from the manufacturer such as engineering drawings, procedures, and manufacturing process
- Potential AI/ML hazards
    - Temperature probes in ovens and gas grills
        - Unattended cooking
    - App controlled toaster oven
        - Turn on automatically

Summary:

- The CPSC deals with physical safety hazards of consumer products such as fire, shock, and impact
- Reduce risk by looking at data regarding common sources of hazards and investigating potentially hazardous products

Differences Among Interviewees:

- Fire program area mostly deals with small ignition sources and other sources of residential fires
- Electrical engineering program area deals with electronic products that could shock or burn users
- AI hazards
    - Electrical - malfunction in the software leading to harm
    - Fire - promotion of bad habits

Similarities Among Interviewees:

- CPSC actions when a product is identified as hazardous:
    - Contact the consumer who was affected to gather information on the safety incident
    - Can purchase the product for themselves or have it given to them by the consumer

    - CPSC will then test the product in their lab to recreate the failure scenario
    - They are also able to request information from the manufacturer such as engineering drawings of the product
    - Could request software, but the CPSC would need an outside expert to analyze the code
- AI hazards - Turn on automatically

3. Appendix C: Project Working Definitions

Artificial Intelligence (AI):
Artificial intelligence is a field of computer science that allows a system to interact with its environment in a manner that resembles human decision-making. An AI system processes information to provide an output based on the given input. It can be used in a systems role to assess information and aggregate answers or in a support role to assure successful operations.

Machine Learning (ML):
Machine learning is the process of a system gaining knowledge or experience from given data and improving its performance over time without being explicitly programmed. It involves monitoring information to assess outputs, measuring to find differences or adaptations, and creating a comparative or temporal model to characterize outcomes.

Physical Harm:
A source of bodily pain, injury, or cause of an illness suffered by an individual.

Safety:
Safety is the state of being protected from physical harm.

Hazard:
A hazard is a potential source or a situation that increases the likelihood of a physical harm to an individual or group of individuals beyond some accepted threshold. Examples could include mechanical contact, hazardous energy release, exposure to hazardous chemicals, or other means of physical harm from a product. *Note: an accepted threshold varies across products, industries, regulators, and consumers; determining this threshold is beyond the scope of this project.*

4. Appendix D: Title

4.1 AI Components List

Component	Description	Examples
Data Source	A common form of a data source is a sensor. Sensors are electronic devices that take the state or changes in the state of the outside environment and quantify them often to be used by some kind of processor.	
Proximity (Ultrasonic) sensor	Devices which utilize reflected or transmitted ultrasonic waves to detect a presence. Typically these detect whether a target is in range or not. These tend to be blind in close proximity, but very effective at range. Tend to be affected less by smoke, gas or other airborne particles	Self parking technology, anti-collision detection, level sensors, ultrasound scanners, security camera
Proximity (Infrared) sensor	Devices which utilize fields, beams or light to detect a presence or movement. These devices tend to work for identifying ambient light, speed, proximity, and movement sensors. Typically these are split between active and passive IR sensors. PIR tends to work with motion based detection, while Active IR both emits and detects IR radiation.	Security camera, automatic lights, obstacle detection, proximity sensors, motion trackers
Temperature sensor	A device which detects the temperature in a specific area. Used to display the current temperature of the area or control the device after reaching a certain temperature.	Overheat detection in phones, refrigerator regulator, 3D printers, higher end soldering irons

Sound Sensor	Sound is transmitted through waves in the air which this sensor measures using a membrane connected to an electromagnet and as the air moves the membrane a corresponding electrical signal is generated in the electromagnet.	Microphone
Color Sensor	A color sensor is a type of photoelectric sensor. It emits light on an object either as white light or as red green and blue light respectively. The sensor then measures the levels of red green and blue light returned and transmits them as 3 electrical signals from which the color can be determined.	Color printing, color calibration, cosmetics, paint, textiles
Light Sensor	More commonly known as photo sensors, they take an input from the photons hitting the sensor and convert them to an electrical signal.	Ambient light detection, Time of day detection
Gyroscope	A device used for measuring the angular velocity and orientation of the object.	Mobile Devices, Cameras, Race Cars, Airplanes, Motorboats, Space Shuttles
Accelerometer	A device which measures the change in velocity of an object. Typically based for axis based motion sensing.	Anti-collision detection, aircraft G-Meters, medical devices, airbags, Segway
Algorithms	The software or code in a system that allows for the device to make decisions.	
Decision making	The act of a product or AI system making choices autonomously.	“If-then” statements
Computation	Computation usually requires a central processing unit (CPU). A CPU manipulates data collected from sensors	

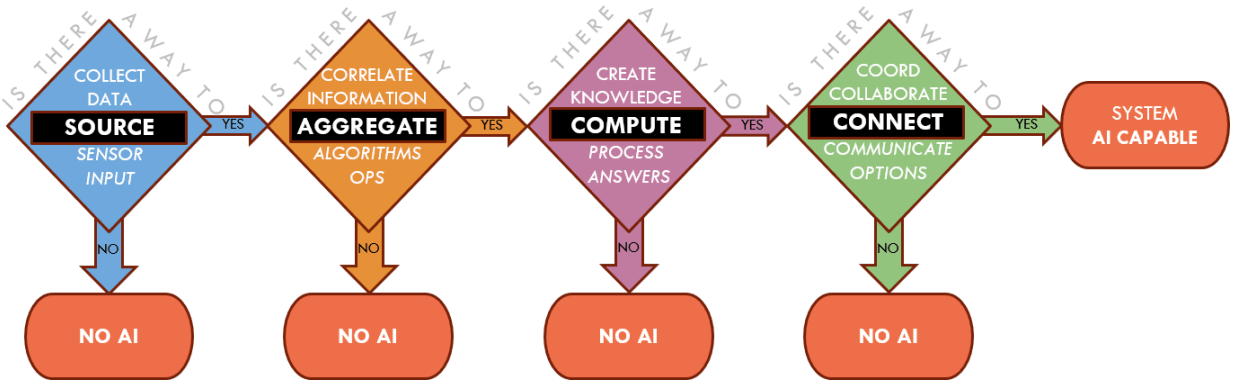
	to allow the system to make intelligent decisions.	
Microcontroller	Small computer designed to read and respond to input.	Remote control devices, appliances
Embedded Processor	Processor within a system that controls the mechanical or electrical functions of the device.	Automobiles, appliances, mobile phones
Microprocessor	A processor that is stored and implemented on a single chip. Nearly all modern processors are microprocessors.	Systems that incorporate an on-board computer
Connection	The linkage through networks that allows for the flow of information throughout the system.	
Data bus	An electronic point to point connection for the purpose of transferring binary code through a system.	Computers
Internet of Things (IoT)	A group of connected products that send data to the cloud to be processed. Information is then sent back to the device so that the device may respond.	Smart watches, smart appliances, home security systems

4.2 ML Components List

Component	Description	Examples
Monitoring	Distinctions	
Qualify	Assesses outputs to observe the given information.	A voice recognition tool that takes in a user's speech.
Measuring	Differences	
Quantify	Analyze adaptations to find differences within the data.	An image processing application that finds the differences between two or more images.
Modeling	Differentials	
Characterize	Enables the system to Enlighten/Empower/Evolve so that it may improve over time.	A vacuuming robot that develops a model of the rooms it vacuums in order to navigate its environment.

5. Appendix E: Decision Trees

5.1 AI Decision Tree



5.2 ML Decision Tree