“Catching Deadly Butterflies”

Building an artificial intelligence model to detect PFM-1 anti personnel mines

Exploded Landmine
Shutterstock. (n.d.). *Torn anti-personnel mine damaged by explosion, petal* [Video]. Shutterstock. https://www.shutterstock.com/video/clip-1104206771-torn-anti-personnel-mine-damaged-by-explosion-petal

Introduction

I was introduced to Artificial Intelligence Machine Learning (AIML) when I joined the University of Arizona Girls Who Code in 2022. My first successful AIML project was a cat vs dog classifier. I then created a chihuahua vs blueberry muffin classifier. Next, I wanted to apply what I learned about AIML from Girls Who Code to a real word problem to help people.

I learned on the news about the PFM-1 anti-personnel mines and how they are maiming people in the war between Ukraine and Russia. The PFM-1 mines are hard to spot, and I wondered if I could make an AI program that shows if the mines are in an area or not.

Girls Who Code
Code, G. W. (2025, July 30). *Girls who code*. Girls Who Code. https://girlswhocode.com/

Blueberry Muffins or Chihuahua
Daesol. (2024, January 7). *Muffin or chihuahua: Confusion matrix and the base rate fallacy*. Neurabites. https://neurabites.com/muffin-or-chihuahua/

For my spring Girls Who Code project my classifier was able to correctly identify a chihuahua vs blueberry muffins with high accuracy and won most liked Girls Who Code project. Can you tell which is muffin and which is a chihuahua?

The PFM-1 Anti Personnel Landmine

Did you know some mines can be mistaken for toys?

PFM-1, also known as the Deadly Butterflies, are mines about the size of a hand. PFM-1 were used in Afghanistan by Russia and are currently being used in Ukraine. Some characteristic of the PFM-1:

- Easily explode; it only take a little bit of pressure to detonate them.
- Are difficult to detect because they are small.
- Children think they are toys and pick them up (Hambling, 2022).
- Farmers cannot see them because they blend into the background(*Landmines in Ukraine*, n.d.).

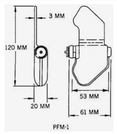
PFM-1 are made to maim, not kill, to fill up hospitals. They also pollute farmland when detonated (*Landmines in Ukraine*, n.d.).

Removal of the mines is slow and dangerous. Experts say that it will be decades before all the mines will be cleared (Wordsworth, 2023). **We need solutions new tools and to safely determine if there are mines in an area.**

Photo of 3-D printed landmine models: Photo taken by Finalist, 2025

Photo of Toys: Photo taken by Finalist, 2025

PFM-1 Landmines are often mistaken for toys



PFM-1

Ago, J. T. M. 1. Y. (n.d.). *protipěchotní mina : Russia / Soviet Union (RUS / SOV)*. Armedconflicts.com. protipěchotní mina : Russia / Soviet Union (RUS / SOV)

Materials

- 3-D Printed Models of the PFM-1, Spray Paint, Access to Teachable Machine Website, and Computer
- **Training Images:** Because I could not find many images of the PFM-1 on online, I had to take pictures of my own using 3-D printed models in different environments.
  - Rocks, grass, leaves, dirt, snow[1], and asphalt were selected because these environments are where PFM-1 are most commonly found in Ukraine.

[1] Since we live in a desert, I used white poster board for snow

Photo of 3-D printed landmine models and along with different background environments: Photo taken by Finalist, 2025

Research Question / Hypothesis

Question 1: "Can an AI model trained with Teachable Machines find PFM-1 landmines on different backgrounds in pictures with at least 80% accuracy?"

- 80% demonstrates success in identification but leaves room for future improvement with better tools and better models (*Teachable Machine*, n.d.).

Question 2: How does training an AIML classifier with diverse backgrounds impact its accuracy and precision in identifying landmines?

Hypothesis: A diverse dataset will increase model accuracy by 20%.

- I know that better data helps AIML models. 20% increased accuracy can show improvement and is not unrealistic.

Testing with Real World Images

- I tested the AI using images I found online to see how well the model could work in real-world settings with different and tricky backgrounds.

Mosaic of images of PFM-1 landmines (adapted from Getty Images, 2002; DroneBelow, 2018; Shutterstock, n.d.; Wikimedia Commons, 2014; Zmina Human Rights Centre, 2023; and others, see References).

- The Teachable Machine website is a beginner friendly tool that allows quick training and testing of AI models.
- To evaluate how well the AI model works with real world examples, I searched the internet for pictures of PFM-1 mines in realistic settings
  - These images feature PFM-1 mines in tricky scenes. E.g., forest with many mines, one with a mine partially showing, mines in mixed / cluttered background environments.
  - I also found images that featured only background environments (e.g., no mines).
- I used a total of 33 images (17 with mines, 16 without/background-only).

Flow Chart For Classification Steps

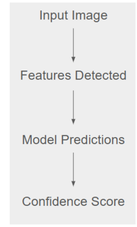


Chart created by Finalist, using PowerPoint, 2025

Procedure

Step 1
Check online for existing images: Due to the fact that I couldn't find existing images, I had to create my own.

Step 2
Print 3D models of the PFM-1: Look online for an open source design of the mine. This will be a physical replica that matches the PFM-1's features and dimensions. Spray paint the model to match the most common colors (green, tan, brown) of the PFM-1.

Step 3
Collect training data: For each color of the PFM-1 replica, take 100 photos with it placed in each of the different background environments.

Take 300 photos of just the background environments (no replica in the image). 300 photos are needed to match the 300 photos taken from above.

Step 4
Prepare dataset: Organize the data sets into categories based on color of PFM-1 model and the background environments.

Step 5
Train the model: Load the model into the Teachable Machine website. This teaches the model to look for the features of each image and builds a classifier with 2 classes (mine vs background-only).

Step 6
Test model: Load images from the internet to test the model. See"Testing Real World Models" for examples.

Step 7
Data Analysis : Measure the confidence score to see if the classification is correct. Calculate model's accuracy.

Photo of 3D printer at work printing a PFM-1 model: Photo taken by Finalist, 2025

Results

Image #	Truth	Complexity	Rock	Leaves	Snow	Grass	Dirt	Asphalt	All
1	Landmine	Hard	100	100	100	76	100	100	98
2	Landmine	Hard	3	8	99	43	100	100	0
3	Landmine	Easy	100	100	100	100	100	100	100
4	Landmine	Easy	100	100	100	100	100	100	100
5	Landmine	Easy	100	100	100	100	100	100	100
6	Landmine	Medium	100	100	100	51	100	100	100
7	Landmine	Easy	100	100	100	100	100	100	100
8	Landmine	Hard	100	100	100	89	100	92	100
9	Landmine	Easy	100	100	100	100	100	100	100
10	Landmine	Easy	100	100	100	100	100	100	100
11	Landmine	Hard	1	25	78	11	100	100	0
12	Landmine	Medium	100	100	100	100	100	100	100
13	Landmine	Medium	100	100	100	93	100	100	100
14	Landmine	Medium	100	100	100	100	100	100	100
15	Landmine	Easy	100	100	100	100	100	100	100
16	Landmine	Medium	100	100	100	100	100	100	100
17	Landmine	Easy	100	100	100	100	100	100	100

Image #	Truth	Rock	Leaves	Snow	Grass	Dirt	Asphalt	All
18	Background-Only	75	99	26	56	1	4	100
19	Background-Only	0	4	11	88	0	1	100
20	Background-Only	34	0	40	87	0	9	100
21	Background-Only	2	96	18	88	0	1	100
22	Background-Only	4	100	81	99	100	93	100
23	Background-Only	100	99	44	100	86	26	100
24	Background-Only	7	22	32	100	100	95	71
25	Background-Only	1	98	2	99	64	14	100
26	Background-Only	6	100	4	93	0	0	100
27	Background-Only	100	100	95	100	0	17	100
28	Background-Only	9	79	24	49	0	3	100
29	Background-Only	97	100	6	62	0	0	100
30	Background-Only	0	0	9	94	76	13	0
31	Background-Only	12	99	14	97	50	32	100
32	Background-Only	99	100	92	100	100	78	100
33	Background-Only	100	14	33	78	40	75	100

Table created by Finalist, using Excel, 2025

Key

- **Image #**: The number for each picture.
- **Truth**: The label for the image (e.g., "Landmine" or "Background").
- **Complexity**: Difficulty level in detecting the landmine (Easy, Medium, Hard).
- **Rock, Leaves, Snow, Grass, Dirt, Asphalt**: The AI model was trained with only these to detect landmines in different environments.
- **All**: The AI model trained using all the background types to detect landmines in diverse settings.

- The confidence score shows how sure the AI is that it found a landmine. A higher score (as a percentage) means it's more confident, while a lower score means it's less sure.
- Some images are just backgrounds with no landmine, like rocks or leaves. They still get a score if the AI thinks it's a background-only image.
- How to read the table: For Image #1 (has a mine), the confidence score is 100%, meaning the model is sure it detected a landmine when tested against the models trained with images of rocks, leaves, snow, dirt, and asphalt.

Discussion

- We can show how diverse backgrounds impact model outcomes by calculating accuracy and precision.

	Rock	Leaves	Snow	Grass	Dirt	Street	All
Accuracy	63	75	66	90	72	63	90
Precision	88	82	100	88	100	100	88

Table created by Finalist, using Excel, 2025

- Accuracy is the percentage of correct predictions the AI model made.
- Precision is the percentage of landmine predictions that were actual landmines.

$$\text{Accuracy} = \frac{\text{Correct Predictions}}{\text{Total Predictions}} \times 100 \qquad \text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}} \times 100$$

Equations created by Finalist, using Word, 2025

- Training images with different backgrounds helped the AI overall.
  - The grass-only dataset worked well for grass (accuracy of 90%.) but did not work well for other backgrounds.
  - **The combined dataset also had an accuracy of 90% and worked well for all backgrounds.**
- The rocks dataset had the lowest accuracy of 63% because the backgrounds were cluttered and made it hard for the AI model to spot.
- A mix of backgrounds helped the AI model learn the more about the features (shape, color, texture).
- It is obvious that that more data helps the AI but **this project shows how much more data helps - up to 27% improvement** (from 63% for rock to 90% for combined).
- Backgrounds like rocks and asphalt were tricky because of shadows and uneven surfaces.
  - Image 19 (rocks, dirt) and Image 30 (rocks, leaves) were misclassified as a landmine with 0% confidence it was a background-only image.

Work Done By Others

- Traditional landmine detection often relies on metal detection.
  - However, the PFM-1 does not contain enough metal to be reliably detected.
- Many researchers have been using AI to help find landmines by analyzing photos and videos.
  - Some teams use drones to search large areas for things that could be landmines.
  - They often use advanced AI tools that can detect and locate the landmines.
- Instead of finding and locating the landmines, this project teaches the AI to decide whether or not there are landmines in the image.
- Unlike most studies that use complex coding tools, this project will not require programing skills.
- Most studies use pre-existing datasets, but this project created a custom dataset using 3D-printed models placed in different environments.

Scope of Research Project

- This project was to learn more about AIML and see if I could create a tool to identify if there was a PFM-1 in an image.
- From what I had learned in Girls Who Code, I knew I needed a large and diverse image dataset. I looked online and found that there were not many openly available images of PFM-1.
- To create the dataset, I decided to 3D-print models of the PFM-1, place them in various backgrounds, and take photos to create the dataset. I know that the larger and more diverse the dataset the better.
- I used The Teachable Machine website to do this project because it is beginner friendly and does not need coding experience.

Conclusion

- This project was fun, and I used what I learned in Girls Who Code to work on a real-world problem.
- I enjoyed learning more about AI and machine learning and even got to teach my parents about it.
- I created an AI model without needing advanced coding skills.
- **My hypothesis was correct. The model performed with 90% accuracy, and I showed how a diverse dataset helped it work better (>20% improvement).**
- There is a lot of work we could do in the future:
  - Share the 3,000 images I created to help other researchers.
  - Generate more images with mixed and complex backgrounds to improve AI performance.
  - Explore using advanced AI models to not only detect landmines but also locate their positions in an image.

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•Antipersonnel mines in soil… https://www.shutterstock.com/image-photo/mines-antipersonnel-mine-ground-top-2175868105
•Demining video collection… https://www.shutterstock.com/video/search/demining
•Environmental/texture images (grass, leaves, soils, asphalt, brick wall, etc.) (see individual Shutterstock pages at:
https://www.shutterstock.com/image-photo/landscape-view-dry-savannah-seamless-texture-2442068917,
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