One of These Things Is Not Like the Others... Machines Can Learn to Classify Too (Resource Exchange)

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Dr. Marcia Pool is a Teaching Associate Professor and Director of Undergraduate Programs in the Department of Bioengineering at the University of Illinois at Urbana-Champaign (UIUC). She has been active in improving undergraduate education including developing laboratories to enhance experimental design skills and mentoring and guiding student teams through the capstone design and a translational course following capstone design. In her Director role, she works closely with the departmental leadership to manage the undergraduate program including: developing course offering plan, chairing the undergraduate curriculum committee, reviewing and approving course articulations for study abroad, serving as Chief Advisor, and representing the department at the college level meetings. She is also engaged with college recruiting and outreach; she coordinates three summer experiences for high school students visiting Bioengineering and co-coordinates a weeklong Bioengineering summer camp. She has worked with the Cancer Scholars Program since its inception and has supported events for researcHStart. Most recently, she was selected to be an Education Innovation Fellow (EIF) for the Academy for Excellence in Engineering Education (AE3) at UIUC. At the national level, she served as the Executive Director of the biomedical engineering honor society, Alpha Eta Mu Beta (2011-2017) and is an ABET evaluator (2018-present).

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One of These Things is Not Like the Others...

Machines Can Learn to Classify Too

Day in the Life of a Cancer Researcher

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Machine Learning & Cancer Research

Hands-on activities in the context of a societal problem strengthens interest & persistence in STEM careers

Machine learning (ML) is highly popularized as a tool to solve many problems in finance, computer security, and image processing. The use of ML in cancer research has potential to reduce diagnostic time, improve detection, & potentially inform treatment. One component of ML is classification which determines if features are similar or different in a series of pictures. The game, "One of These Things (Is Not Like the Others)" popularized by Sesame Street, can be used to introduce students to this complex algorithm.

This free teacher resource kit contains three activities to introduce students to what cancer researchers are studying: (1) removing cancer cells using Play-Doh, (2) a wavelength tissue penetration activity to introduce key components of imaging tissue (taking pictures of body parts), and (3) the Classification Game to show how ML can contribute to the process.

ML Classification Game - Making Rules

One of the main ML algorithms is classification - does an image belong to one group or another. Looking at the picture of cats and dogs above we could write several rules for classification. Rule 1: 3 cats vs. 1 dog. Rule 2: One pet is entirely black while the other pets have some white. However, what if we introduced a picture of a turtle? In which category would it be placed? (Classification Phase) Or would I need to re-think the rule? (Testing Phase)

1 AGE RANGE

Designed for 2nd & 3rd graders. (With tips for using with older students)

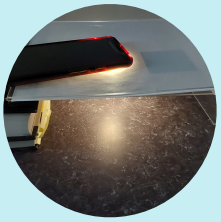
2 LOW COST SUPPLIES

Supplies: paper, flashlight, plastic, Play-Doh, and a color printer

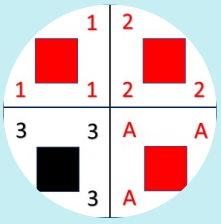
3 NEXT GENERATION SCIENCE STANDARDS

1-PS4-2, 1-PS4-3, 3-5-ETS1-3, and 2-PS1-1 [1].

Remove Cancer
Using Play-Doh, students attempt to remove "cancer"



Imaging Tissue - Wavelength Penetration
Using a flashlight, find max # of layers



Classification Game
Learn the basics of ML through a card game.

[1] NGSS Lead States, "Next Generation Science Standards: For States, By States," 2013. [Online]. Available: https://www.nextgenscience.org/. [Accessed: 19-Feb-2023].

Day in the Life of a Cancer Researcher

Task: Help the doctor treat patients by determining which tissue is healthy and which tissue is cancerous and should be removed.

Why: Early detection improves patient well-being; accurate detection can reduce the number of repeat procedures to remove existing bad (cancerous) tissue.

Cancer: The human body is made up of many parts (skin, heart, lungs, etc.) which are commonly referred to as "tissue" (e.g., skin tissue, heart tissue, lung tissue). These tissues are made up of many small things called "cells". Healthy (normal) human cells grow to mature size then stop growing, function, and are replaced by new cells, as needed [2]; it is like leaves on a tree (they grow in spring and summer; reach maturity and fall off in fall and winter; then repeat the cycle again). However, if the process instructions telling the cell to "stop growing" are not followed, the cell has "cancer", which means the cells will continue to grow [3]. This is similar to how an invasive species [4,5] takes over an area (e.g., invasive reptiles in Florida). To restore the ecological balance in an area after an invasive species invades, the invasive species must be removed. The same process happens with cancer; doctors remove the cancer from the body to restore health to the patient.

[2] M. Fischetti and J. Christiansen , "Our bodies replace billions of cells every day," Scientific American, 01-Apr-2021. [Online]. Available: https://www.scientificamerican.com/article/our-bodies-replace-billions-of-cells-every-day/. [Accessed: 12-Feb-2023].

[3] "Cancer," Genome.gov. [Online]. Available: https://www.genome.gov/genetics-glossary/Cancer. [Accessed: 12-Feb-2023].

How do we detect cancer? There are many different types of cancer, yet many are first suspected through common medical exams (e.g. annual doctor visits, blood work). Once cancer is suspected, a picture (image) is needed to learn more. The picture can be taken using different types of medical machines [6] such as Magnetic Resonance Imaging (MRI) which we will discuss here.

Analysis of the image by humans: Skilled doctors (radiologists) look at an image and determine what parts are normal and what parts are cancerous. *Activity 1* demonstrates how certain areas are easy to classify as cancerous, but the areas around normal tissue may also be cancerous, just not as easily seen.

Acquiring an image (picture): MRIs work by using magnets and radio waves to align water molecules in the body. This process allows a black and white image (picture) to be created. *Activity 2* introduces students to the concept of using waves (easily seen visible light waves in this example) for imaging.

Analysis of the image by computers: A computer is "trained" to look for cancerous areas by showing it many previously analyzed (by radiologist) images that classify normal and cancerous tissue. *Activity 3* introduces students to the concept of classification through a card game and writing rules (i.e., training the algorithm).

[4] M. Martin, "Comparing Invasive Species to Metastatic Cancers Inspires New Insights for Modelers," JNCI: Journal of the National Cancer Institute, Volume 100, Issue 2, 16 January 2008, Pages 88–89, https://doi.org/10.1093/jnci/djm315

[5] J. Noorbakhsh, Z.M. Zhao, J.C. Russell, J.H. Chuang, "Treating Cancer as an Invasive Species," Mol Cancer Res. 2020 Jan;18(1):20-26. doi: 10.1158/1541-7786.MCR-19-0262. Epub 2019 Sep 16. PMID: 31527151; PMCID: PMC6942216

[6] "Imaging (Radiology) tests for cancer," American Cancer Society, 30-Nov-2015. [Online]. Available: https://www.cancer.org/treatment/understanding-your-diagnosis/tests/imaging-radiology-tests-for-cancer.html. [Accessed: 12-Feb-2023].

INTERESTED? THIS IS ALL FREE TO DOWNLOAD! SCAN THE QR CODE TO SEE THE FILES!

Teacher Resource Kit for Machine Learning (ML) Applied to Cancer Research

The authors have made the entire kit free to download from a Google Drive (link: https://tinyurl.com/mryuua72 or using the QR code provided). This drive contains not only all the activity information to help teachers integrate the activities into their classrooms but also background information, lesson plans, and variations for middle school and high school students. The authors encourage you to share this information with other teachers!