Computer Aided Detection (CAD) of Lung Nodules using LDCT in the IB Biology Classroom

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International Baccalaureate | Hillsborough County Public Schools — Preparing Students for Life

Integration Theme: How **Low-Dosage Computed Tomography** (**LDCT**)) and **Computer-Assisted Detection** (**CAD**) systems aid in early identification of lung cancer nodules.

Mission & Goals

Teach students biological concepts including:

- Cancer is the result of cumulative genetic mutations.
- Personal risk factors and environmental mutagens influence DNA expression and the cell cycle.
- Benign, malignant, and metastatic tumor development and characteristics.

Expose students to practical applications of computer vision in biomedical imaging by

- Conducting LDCT-based analysis of metastatic nodules using 3D-Slicer.
- Facilitating student understanding of convolutional neural networks in CAD, and the implications of deep learning in medical imaging.

Background

- Lung cancer represents 14% of all new cancer diagnoses, and is the leading cause of cancer death (26%) in the US.
- As baby boomers age, a 52% increase in diagnoses is expected by 2030. (Smith, et al. 2009).
- Diagnosis usually occurs late, reducing treatment success. False negative rates using x-ray screening are as high as 25%. (Stapley, et al. 2006)
- Use of LDCT screening is associated with a 15-20% reduction in mortality risk compared with chest X-rays. (NLSTRT, et al. 2011). Annual screening via LDCT may reduce cancer deaths as diagnosis rates increase.
- Traditional secondary biology introductory courses spend little to no time on medical imaging. **As diagnoses are expected to increase, so should our preparation of the next generation of medical and technical professionals.**

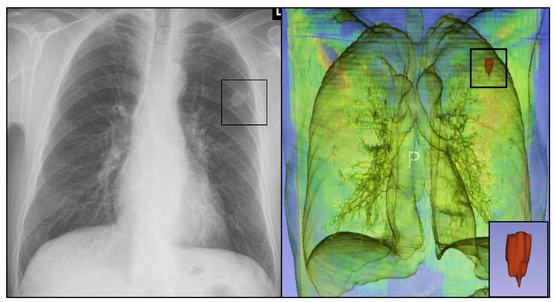


Fig. 1. Comparison of similar lung nodules using chest x-rays (left) and LDCT with segmentation and volume rendering in 3D Slicer (right). Chest x-ray: (wikimediacommons.org, lange123)

Lesson Prep:

Flipped Session (90 min.)

1. Dr. Bert Vogelstein discusses how cumulative genetic mutations lead to tumor growth and spread in the HHMI Lecture: "Putting the Brakes on Cancer".
2. Download and install 3D slicer and patient data.

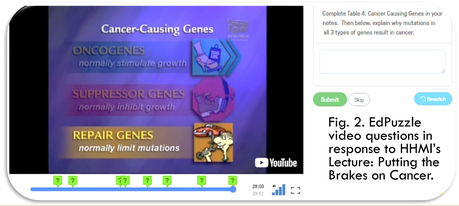


Fig. 2. EdPuzzle video questions in response to HHMI's Lecture: Putting the Brakes on Cancer.

Lesson Outline

Class Day 1: (90 min.)

1. Meet Laura McCracken: 30 yr. old non-smoker, vlogs about her Stage 4 SCLC diagnosis in 2008 (Fig. 3)
2. Lung Cancer Basics: statistics & epidemiology (Fig.4), compare and contrast detection technologies including X-rays, MRIs, PET, and LDCT.
3. 2D Diagnostic: Simulate x-ray screening using static LCDT scans to assess nodule characteristics (size, shape margins, density, est. volume) (Fig. 5) and stage. (Fig. 6).

Evidence of Learning:

- Meet Laura Reflection Log
- Nodule 2D Diagnostic Results

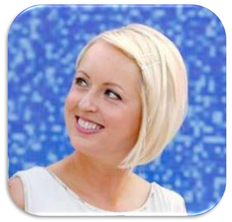


Fig. 3. Laura McCracken (www.webwawa.com)

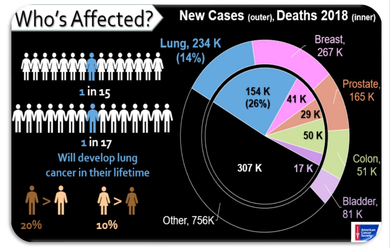


Fig. 4. Basic lung cancer statistics 2018 (www.cancer.org)

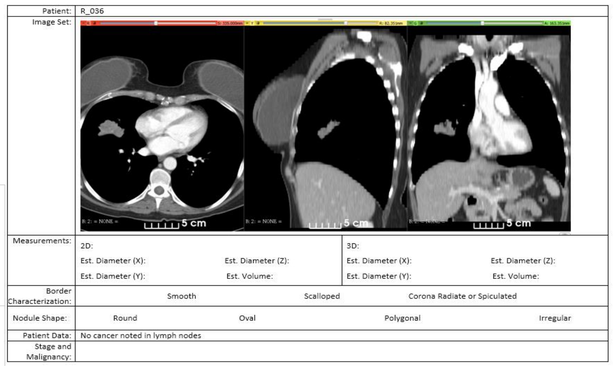


Fig. 5. Patient Data Sheet provided to students for X-ray screening diagnostic simulation. Students use 2D scans to assess lung nodule characteristics and disease stage.

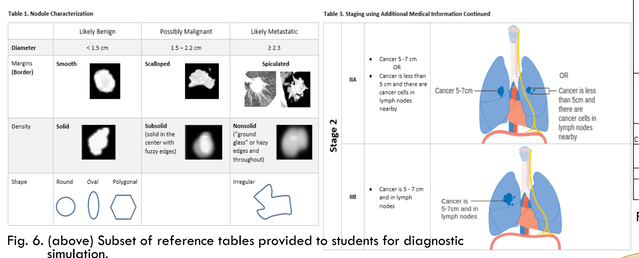


Fig. 6. (above) Subset of reference tables provided to students for diagnostic simulation.

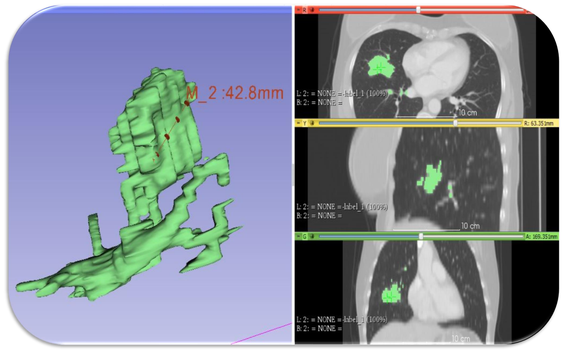


Fig. 7. Students re-analyze patient data using segmentation and volume rendering in 3D slicer. Results are compared to 2D x-ray screening diagnostic activity.

Class Day 2: (90 min.)

1. Check in with Laura: Laura vlogs about her progress.
2. 3D Slicer Tutorial: Utilize 3D Slicer to characterize lung nodules in a step-by-step tutorial.
3. 3D Diagnostic: Re-analyze nodules using segmentation and volume rendering in 3D slicer (Fig.7) and compare with 2D Diagnostic results.
4. Meet Sir Geoffrey: Video bio of Geoffrey Hinton, the "father of deep learning", and how A.I. is used in the real world.

Evidence of Learning:

- Meet Laura Reflection Log
- Nodule 3D Diagnostic Results

Class Day 3: (90 min.)

1. Computer Vision Presentation: Focuses on the concepts of edge detection, segmentation, deep learning, neural networks, and how these concepts are used in CAD.
2. Computer Vision Assignment Choice:
   - Draw, label, explain how a convolutional neural network might work for lung nodule detection. (Fig. 8)
   - Write a short essay on deep learning in medical imaging using the MIDL 2018 Panel discussion & other resources.
   - Conduct 3 additional nodule analyses using 3D slicer and compare results with a partner
4. Saying Goodbye to Laura: Read Laura's posts revealing her terminal diagnosis after 7 yrs in remission. Reflection on her story, including how early diagnosis with CAD may have changed her outcome.

Evidence of Learning:

- Meet Laura Reflection Log
- Computer Vision Assignment Choice (deadline extended)

Computer Vision Connection

The bridge between biology and computer vision is reinforced by exposing students to the following concepts and applications:

- Region-growing as a means of segmentation of tissues.
- Use of computer algorithms to detect lung nodules at sizes smaller than detected manually.
- Use of convolutional neural networks in CAD
- Industry level implications of deep learning in medical imaging.

Introductory computer vision presentation was developed using information and materials provided by

- Rodney LaLonde, UCF CRCV
- Sarfaraz Hussein and Dr. Ulas Bagci's research regarding risk stratification using 3D-CNN based multitasked learning.
- Dr. Bagci's Medical Image Computing Lectures
- 1Blue3Brown video lecture series by Grant Sanderson of Stanford's Educational Studies program

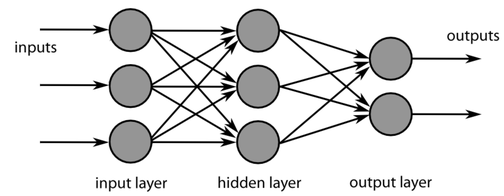


Fig. 8. Framework for students to conceptualize and explain a CNN model for lung nodule detection. (de.Wikipedia.org: MultiLayerNeuralNetwork_english.png: Chrislb)

References

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