[**Link**](https://drive.google.com/open?id=114onbQyoTlErN0SfD1rW2P3sq45jZqN3) **to Poster**

**PROJECT ABSTRACT:**

Over fourteen million people are diagnosed with cancer per year and about fifty percent of these individuals could benefit from radiation treatment. Radiation aims at destroying cancer cells; however, during this process, healthy surrounding cells are impaired. An obstacle often faced during radiation therapy is that certain tumors like those found in the lungs are in constant motion. In order to minimize the destruction of healthy cells, tumors need to be targeted directly. Tumor tracking is tracking the periodic motion of a tumor within an organ. In this project, we were given data depicting the movement of a phantom lung tumor, i.e. an artificial tumor. The goal of our project is to track the motion of the phantom tumor by looking at images of the tumor over time and applying Kalman filters. Kalman filters allow for precise predictions of the tumor’s whereabouts to ensure accurate radiation treatment is applied. As a result, we are able to predict the tumor’s location at any given time, which can result in a more precise radiation treatment.

**INSTALLATION GUIDE:**

-Download the anaconda distribution of python: [link](https://www.anaconda.com/distribution/)

-Several external packages were used that are not native to anaconda, execute the following lines into the Anaconda prompt to install the required packages:

-conda install -c menpo opencv

-conda install -c conda-forge pykalman

-conda install -c conda-forge moviepy

-Download and extract the zip file of the code to your desired directory: [link](https://drive.google.com/file/d/1kXM6hv0ji99mkAmdjpcH2jvWu98rth3A/view?usp=sharing)

**DEVELOPERS GUIDE:**

-Data Description (from John Roeske):

We have images (DICOM format) of a simulated tumor (spherical) on both single energy and dual energy images. The difference between the two is that single energy images are acquired with one x-ray energy, and as such will have obstructions such as ribs, etc. The dual energy images are acquired using two separate energies, and a weighted log subtraction is performed to remove the ribs. However, due to the subtraction, these images tend to have a higher level of noise content, compared with the single energy images.

-The data we were working with is DICOM images, DICOM images require software to be viewed and exported into other formats. Our selection for software was MicroDicom: [link](http://www.microdicom.com/downloads.html)

-MicroDicom was used to export the DICOM images into a WMV (video) format

-ZIP file description:

-120\_DCM - single energy data

-DE\_DCM - double energy data

-Frames - contains cropped frames of the video

-Within frames, several other folders exist:

-Grayscale- grayscale version of frames

-Gaussian- filtered version of grayscale images

-Kalman- kalman output of center point

-Center- kalman output of center point (cyan) AND measured center point (gold)

-In addition to the aforementioned folders, there are 4 .ipynb i.e. Jupyter Notebook files:

-Tracking Tutorial - this is the tutorial code for [this](https://www.hdm-stuttgart.de/~maucher/Python/ComputerVision/html/Tracking.html#kalman-filter) tutorial given by John; independent of other 3 files

-Video Manipulation - this is the code which crops the exported wmv video (from DICOM images) and does the manipulation of the video to capture the cropped individual frames of the video

-Tumor Center - this is the code which takes the individual frames (from Video Manipulation) and applies gets a measured center point of the tumor

-Tracking Tumor - this is the code which takes the measured center point of tumor (from Tumor Center) and applies the Kalman filtering

-Brief explanation of Kalman filters:

Kalman filtering is an estimation algorithm that estimates the state of a system based on noisy observations (inaccurate measurements) uses past observations and current observations to make a less noisy prediction.

-Where to begin:

-General note: If you are using a mac, you will need to update the directories

-Start by going through the tutorial (link above) and using the Tracking Tutorial Jupyter Notebook as a reference

-After this, go through Video Manipulation notebook

-Once you go through Video Manipulation, you have the frames that are necessary to work with the Tumor Center notebook

-Proceed to the Tumor Center notebook

-NOTE: the code working towards a generic filter is not yet functioning, you do not have to run that section yet

-Following the Tumor Center notebook, you have the measured center pixels plotted in gold

-Proceed to Tumor Tracking notebook

-The Tumor Tracking notebook applies the Kalman filters and overwrites the center pixel frames (from Tumor Center) to include the Kalman filter output as well

-These frames were then stitched back together via [this](https://ezgif.com/maker) gif maker

-You can export to other forms than gif if necessary through the above link

-Where to go:

-The code at this stage relies on the tumor being circular due to using a circular filter in Tumor Center

-Future versions of this code should allow for a generic filter to be created by allowing a user to trace the tumor and creating a filter to match this shape

-Some efforts have been made in this direction at the bottom of the Tumor Center model, but the generic filter 2d convolution output was not the desired result, it should resemble the Gaussian filter 2d convolution output

**GENERAL DESCRIPTION OF PROJECT:**

* Goal: Accurately track the movement of a circular, phantom (i.e. artificial) tumor using Kalman filters
* Process:
  + Calculating the Tumor’s Center Point for each Frame
    - Started by accessing the DICOM images of the x-ray using MicroDicom
    - The tumor was then located in a single frame
    - After this, a gaussian filter was applied to make the tumor more distinguishable among the image
    - The center of the tumor was then calculated and marked by taking the median of the tumor’s 9 darkest pixels
    - These steps were repeated for all of the frames
    - Once completed, all of the frames were stitched together to create a video tracking the calculated center point of the phantom tumor
  + Applying the Kalman Filter to Track the Tumor’s Center Point
    - The Kalman filter was applied to the frames and compared side by side with the calculated centerpoint of the tumor
* Results:

-After applying the Kalman filter, we were able to obtain prediction points of the phantom tumor’s whereabouts and compare them with what was actually measured.

-These prediction points were relatively similar albeit more accurate to what was actually measured, thus allowing for an accurate tracking.

* Conclusion:
  + Kalman filters were used to predict the tumor's location allowing the tumor’s center pixel to be accurately tracked at any given time.
  + This would result in radiation therapists having a clearer estimate on the center of the tumor and allow them to ensure that the radiation is directed mainly on the tumor to reduce side effects that are produced by the high energy x-ray beams.
  + By applying Kalman filters into tumor tracking, patients and practitioners could both benefit. Patients have the potential to have less side effects that is caused by radiation if the radiation can be focused more centrally on the tumor. Practitioners can utilize this technique to create a more direct and precise plan of radiation treatment that radiation therapists will later perform on the patient.