The Tar Kiln Feature Detection (TKFD) workflow
Operating Instructions
Updated: December 8, 2021

Operating System Requirements
Windows, Mac, and Linux

See specific system requirements for running R, R Studio, and FIJI in their respective FAQ and support documentation:

R FAQ: https://cran.r-project.org/doc/FAQ/R-FAQ.html
RStudio Support: https://support.rstudio.com/hc/en-us
FIJI FAQ: https://imagej.net/software/fiji/downloads

Required Software
R, R Studio, and FIJI

Follow the download links to the version of these software used to develop the TKFD:

R version 4.0.3: https://cran.r-project.org/
RStudio version 1.4.1103: https://www.rstudio.com/products/rstudio/download/
FIJI version 2.1.0/1.53c https://imagej.net/software/fiji/downloads

South Carolina LiDAR Data
The data used to develop and run the TKFD-workflow were commissioned by the South Carolina Department of Natural Resources and can be found via the NOAA Digital Coast Data Access Viewer (https://coast.noaa.gov/dataviewer/#/lidar/search/) or directly via https://www.fisheries.noaa.gov/inport/item/57112.

Operation Instructions
Setting up R project to run TKFD

1. Download and unzip the TKDA-workflow folder via GitHub or Zenodo.
2. Navigate to the code folder. Within this folder are located the R project file (.Rproj), the R code (.R), the FIJI macro code (.txt), and various folders used to hold or transfer datasets between R and FIJI.
3. To initiate the RStudio project for the TKDA-workflow, first open the "TKFD_workflow_project.Rproj" file in RStudio. This will automatically make the R working directory for the project relative to the where the unzipped TKDA-workflow folder is located. It is fine to move all the content of the TKDA-workflow folder to any convenient location on your computer, but it is important that all of the contents of the folder remain in the folder.

4. Once the "TKFD_workflow_project.Rproj" is open in RStudio, open the "TKFD_workflow_R_code.R" R file in the RStudio project by either double clicking the R file in your OS file explorer, or double clicking the file in the file list window of RStudio.
5. Once the R file is open in the RStudio project, you are ready to begin using the TKDA-workflow.

Loading required packages

1. The packages listed at the beginning of the script are needed to run the TKDA-workflow. Please note that the versions used to develop the TKFD-workflow are provided.
2. In RStudio version 1.4.1103, a dialogue at the top of the coding window will prompt you to install any packages that are not currently loaded in R. The user can follow this prompt or can download and install all of the required packages manually.
3. See instructions for downloading and installing packages in Rstudio here: http://derekogle.com/IFAR/supplements/installations/InstallPackagesRStudio.html

Adjusting LiDAR inputs

1. The TKDA-workflow accesses the LiDAR DEM inputs from the "TKDA-workflow/code/data/Lidar_data" folder.
2. To add additional datasets for the TKDA-workflow to analyze, simply move them into this folder. The files must be DEM raster files in the GeoTiff format. All files must use the same projection information.
3. The downloadable version of the TKDA-workflow includes three example datasets from the Francis Marion National Forest. See **South Carolina LiDAR Data** section above for information on download LiDAR data.

Installing the Circle Hough Transform Plugin for FIJI and optional parameter adjustments

1. Instructions for installing the Circle Hough Transform Plugin for FIJI can be found at: https://imagej.net/plugins/hough-circle-transform
2. This tutorial outlines all of the adjustments that can be made to the Circle Hough Transform when run in advanced mode, however, the parameters used for this study are highlighted in lines 66-73 of the "TKFD_workflow_R_code.R" code.
3. Any adjustments to these parameters must be made in the "FIJI_macro_TKFD.txt" file, located in "TKDA-workflow/code/" folder.

Configuring FIJI for running headless on multiple operating systems

1. The link between R and FIJI is achieved by launching a headless instance of FIJI from the system commands available in R. To achieve this, two criteria must be satisfied:
    a. FIJI must be installed. See instruction for installing FIJI above in **Required Software**.
    b. R must know where to find the FIJI application in order to launch it.
2. Currently, the "TKFD_workflow_R_code.R" code is configured to launch FIJI on a Mac from the Applications folder. If using a Mac, simply download FIJI and move it into the applications folder. The code, as it is written, should work.

3. If not running the TKDA-workflow on a Mac, or if you choose to locate the FIJI application somewhere other than the Application folder on a mac, line 79 or the "TKFD_workflow_R_code.R" code needs to be adjusted.
4. For more information on running FIJI headless, see: https://stackoverflow.com/questions/28770970/running-fiji-imagej-macro-from-terminal

Adjustments for Windows users

Line 79:
system(paste("%USERPROFILE%\Fiji.app\ImageJ-win64.exe --headless -macro ", paste(getwd(), ("/FIJI_macro_TKFD.txt"), sep = ""), paste(getwd(), ("/data/Canny_Edges_Images/"), (lidar.name),("/"),("*"), getwd(), ("/FIJI_output/"), lidar.name, sep = "")))

Replace the highlighted section of code to reflect the computer's user profile name and the location of the FIJI application. Copy and paste this section of code to replace line 79 of the "TKFD_workflow_R_code.R" code.

Adjustments for Linux users

Line 79:
system(paste("~/Fiji.app/ImageJ-linux64 --headless -macro", paste(getwd(), ("/FIJI_macro_TKFD.txt"), sep = ""), paste(getwd(), ("/data/Canny_Edges_Images/"), (lidar.name),("/"),("*"), getwd(), ("/FIJI_output/"), lidar.name, sep = "")))

Copy and paste this section of code to replace line 79 of the "TKFD_workflow_R_code.R" code.

Adjustments for Mac users if FIJI is **not** in the Applications Folder

Line 79:
system(paste("/Applications/Fiji.app/Contents/MacOS/ImageJ-macosx -macro", paste(getwd(), ("/FIJI_macro_TKFD.txt"), sep = ""), paste(getwd(), ("/data/Canny_Edges_Images/"), (lidar.name),("/"),("*"), getwd(), ("/FIJI_output/"), lidar.name, sep = "")))

In the existing code of line 79, replace the highlighted section of code to reflect the location of the FIJI application.

Running the code

1. After the user has made any necessary adjustments to the input datasets or the configurations for running headless instances of FIJI, they simply need to select all of the code (Ctrl+A on Windows; Command+A on Mac) and click run.

Outputs
The TKFD produces a shapefile output containing all tar kilns identified with the input raster. The default map projection for this shapefile is the same as the input map project for the LiDAR DEM raster data. The column names within the shapefile are defined as the following:

Column name	Description
index	A running count of all tar kilns located within the LiDAR DEM input.
op_chunk	The name of the operational chunk that the tar kiln was located in. Operational chunks are designated as the LiDAR DEM raster input file name with an appended chunk number (e.g. "0001", "0002", etc.).
CHT_score	The Circle Hough Transform score generated by FIJI. Values range from 0.0-1.0 See Snitker et al. 2021 for more details.
radius_m	The circle radius derived from Circle Hough Transform performed in FIJI. This radius is approximate and should only be used for reference.
x_coord	The X coordinate for the location of the tar kiln. The map projection used for this coordinate is the same as the raster input map projection.
y_coord	The Y coordinate for the location of the tar kiln. The map projection used for this coordinate is the same as the raster input map projection.
kiln_elev	The average elevation within the interior of the kiln.
out_elev	The average elevation of a buffer around the exterior of the kiln (2x the CHT diameter).

Expected Runtime
The runtime of the TKDA-workflow is dependent on the size of the input rasters and the processing capabilities of the user's computer. The TKDA-workflow was developed and run on a 2020 MacBook Pro with a 1.4 GHz Quad-Core Intel Core i5 processor. The example datasets (n=3) from the 2017 SC DNR Lidar mission (extent: 3km x 3km) were completed in 4.9 hours.

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