Cloud Detection

Final Project

by Shiddharath Patel

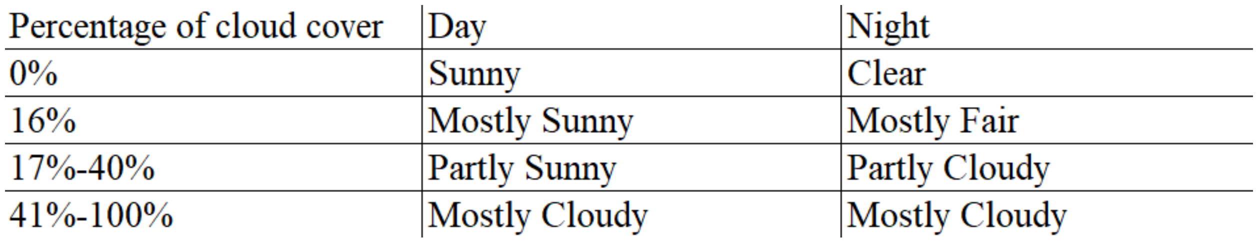
“I pledge my honor that I have abided by the Stevens Honor System.” - Shiddharath Patel

Abstract

The main objective of this project was to create a program that would determine the sky condition given the amount of cloud coverage in an image whether it is daytime or nighttime. The Georgia Forestry Commission, who have set guidelines based on specific percentages of cloud cover, was used to determine an estimated range tailored to this project. The possible scenarios that could result for this program include sunny/clear, mostly sunny/fair, partly sunny/cloudy, and mostly cloudy. The tools used to create this program include C++ with OpenCV in order to import and display images with contour lines around any clouds which would determine the level of sunniness, clearness, or cloudiness in the sky. Additional tools include an iPhone 12 Pro camera for capturing real time photos and selected images from Google. The result of this program was that it successfully determined what sky condition the inputted image was given the set parameters within the code. By finding and adding contour lines around any clouds in the sky, the code gives out a reading based on the aforementioned scenarios which corresponds to the predetermined percentage range.

Accomplished Work Description with Results

In order to successfully create and run this project, the parameters of what a sunny, mostly sunny, partly sunny, and mostly cloudy day and its equivalent night conditions need to be defined. Using the percentage of cloud cover shown in Figure 1, each condition has its breakdown of its classification.



Percentage of cloud cover	Day	Night
0%	Sunny	Clear
16%	Mostly Sunny	Mostly Fair
17%-40%	Partly Sunny	Partly Cloudy
41%-100%	Mostly Cloudy	Mostly Cloudy

Figure 1

In order to build the code to process the existence of clouds and draw contours around it, research was done to see if there were any previous iterations on this specific use case. However, the research came up lacking, so I identified another use case of drawing contours around coins and used that information to assist me in understanding how it would apply in searching for any cloud outlines and adding contours to them.

Once the cloud(s) in a given image have been identified, the code adds contour lines to them, and then counts all the lines and applies them to the given if statements. The range I have given is 0 to 1000. The percentages in Figure 1 have been calculated for an easier way to understand each condition's if statement range. For example, in the partly sunny/cloudy condition, the range for the number of contour lines is 161 to 400 which corresponds to the 17%-40% percentage of cloud cover.

After learning how to input contouring, I added images of different sky conditions to test the code. For the sunny day, the absence of clouds and therefore lack of contours gave out the right condition which is shown in Figures 2 and 3. This corresponds to the 0% percentage of cloud cover from the table in Figure 1. The image in Figure 2 was taken using an iPhone 12 Pro camera.

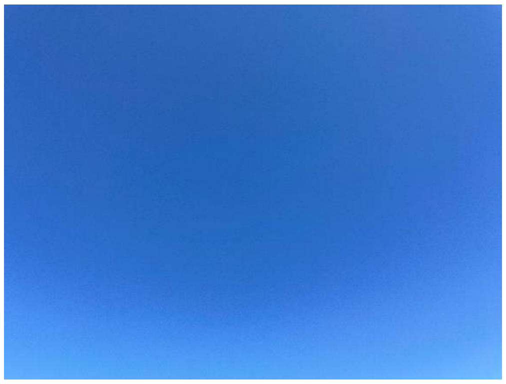
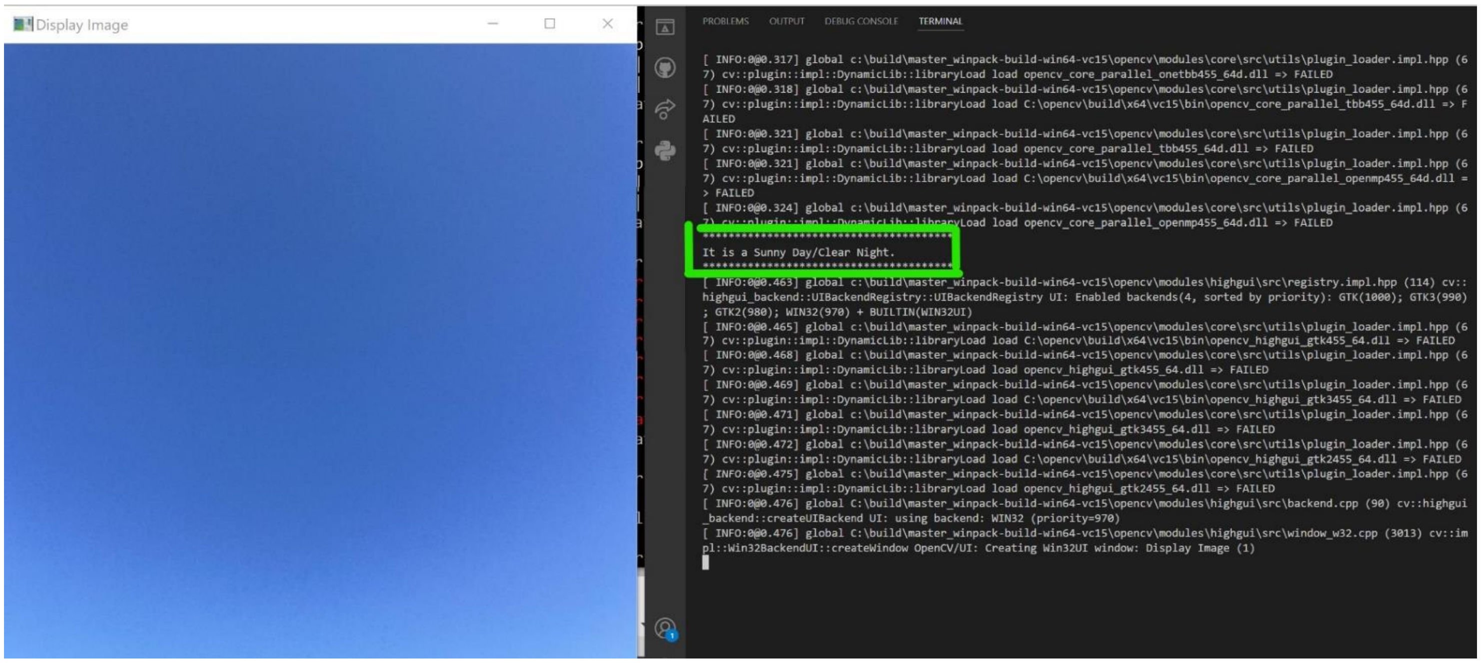


Figure 2- Raw Image



```
[ INFO:0@0.317] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.318] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.321] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.321] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.324] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
**************************************
It is a Sunny Day/Clear Night.
**************************************
[ INFO:0@0.463] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.465] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.468] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.469] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.471] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.472] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.475] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.476] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.476] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 3- Code Output (Sunny Day)

Also, I should note that the code output in the green box includes both conditions of the day and night because it is dependent on the user to know whether the image is daytime or nighttime. The program does not tell what time of day the image is. Figures 4 and 5 include the nighttime condition of the clear night without any clouds.

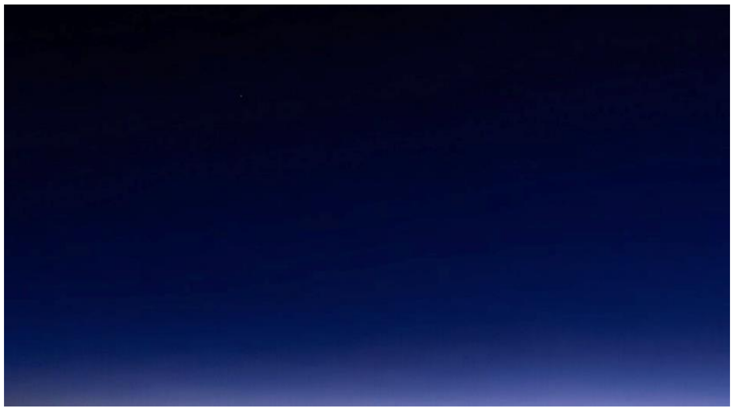
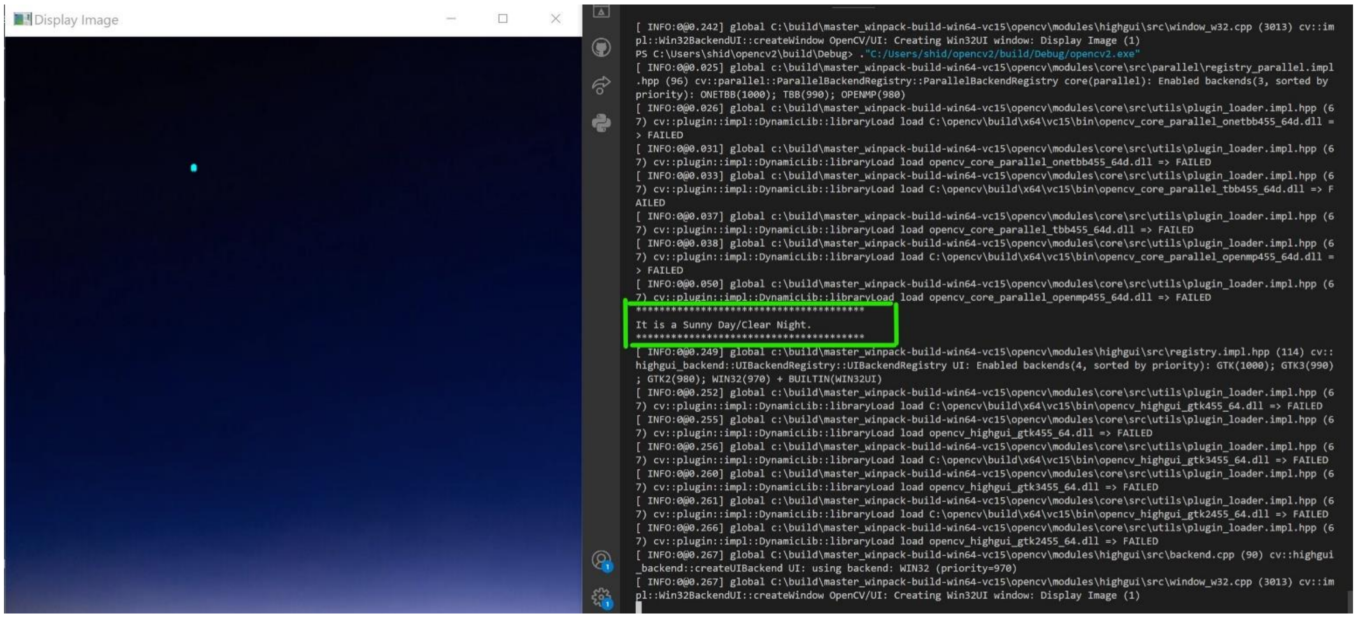


Figure 4- Raw Image



```
[ INFO:0@0.242] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
PS C:\Users\shid\opencv2\build\Debug> ."C:/Users/shid/opencv2/build/Debug/opencv2.exe"
[ INFO:0@0.025] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\parallel\registry_parallel.impl
.hpp (96) cv::parallel::ParallelBackendRegistry::ParallelBackendRegistry core(parallel): Enabled backends(3, sorted by
priority): ONETBB(1000); TBB(990); OPENMP(980)
[ INFO:0@0.026] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_onetbb455_64d.dll =
> FAILED
[ INFO:0@0.031] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.033] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.037] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.038] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.050] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
***************************************
It is a Sunny Day/Clear Night.
***************************************
[ INFO:0@0.249] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.252] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.255] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.256] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.260] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.261] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.266] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.267] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.267] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 5- Code Output (Clear Night)

The next percentage of cloud cover is 16% and its range in the code's if statement is 12-160. This corresponds to the sky condition of mostly sunny for daytime and mostly fair for nighttime. This is shown in Figures 6 and 7. In Figure 7, the program successfully added the contour outline to the single cloud from the raw image. This also visually makes sense as the image in Figure 6 is generally associated to be a mostly sunny day to the average observer.

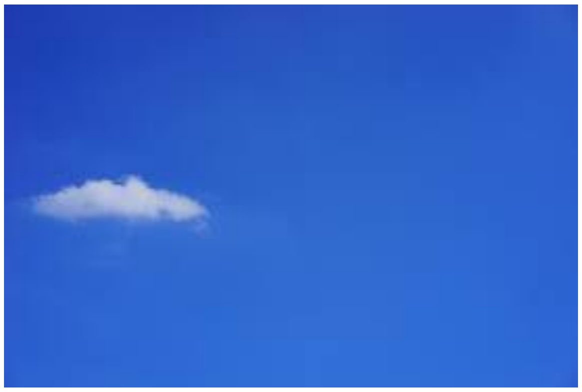
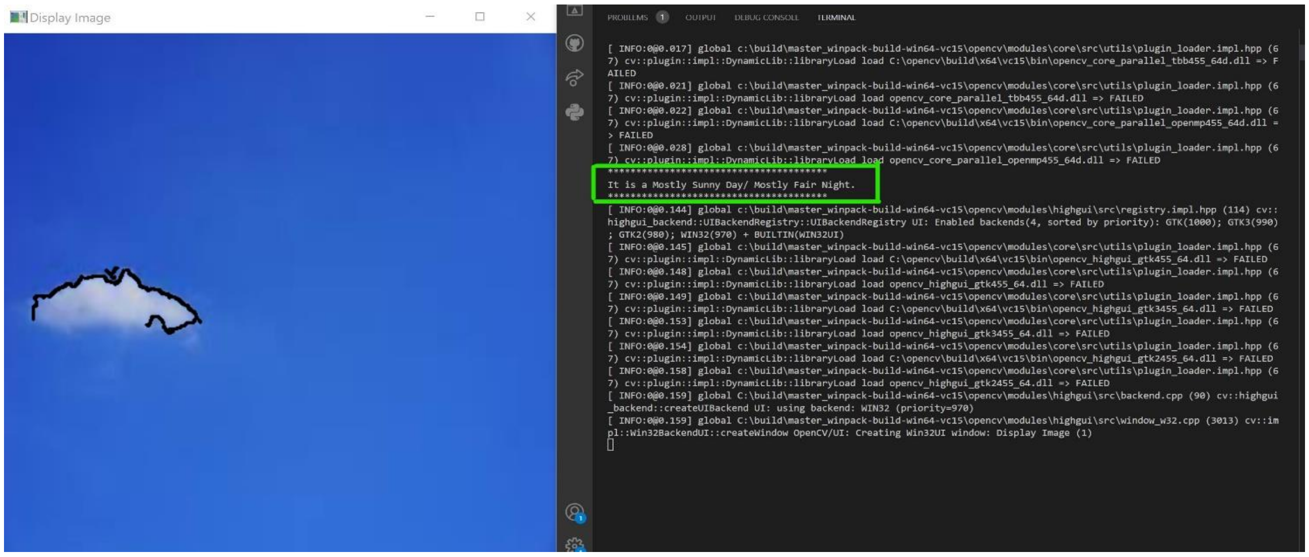


Figure 6- Raw Image



```
[ INFO:0@0.017] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.021] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.022] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.028] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
**************************************
It is a Mostly Sunny Day/ Mostly Fair Night.
**************************************
[ INFO:0@0.144] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.145] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.148] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.149] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.153] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.154] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.158] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.159] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.159] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 7- Code Output (Mostly Sunny Day)

Figures 8 and 9 show the mostly fair condition for the nighttime. The image in Figure 9 is cropped due to the code resizing the image to 512x512 pixels. The image in Figure 8 was taken using an iPhone 12 Pro camera.

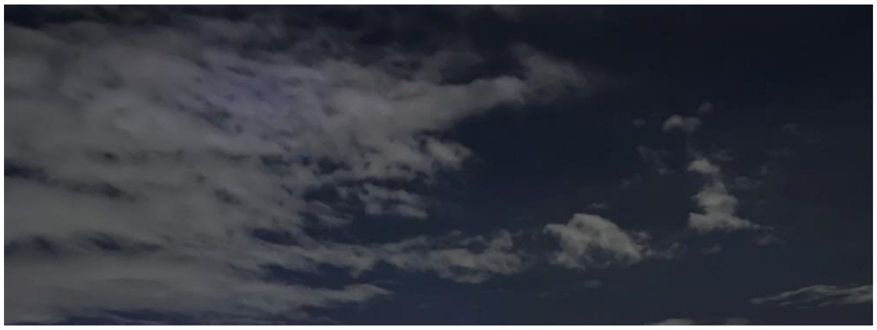
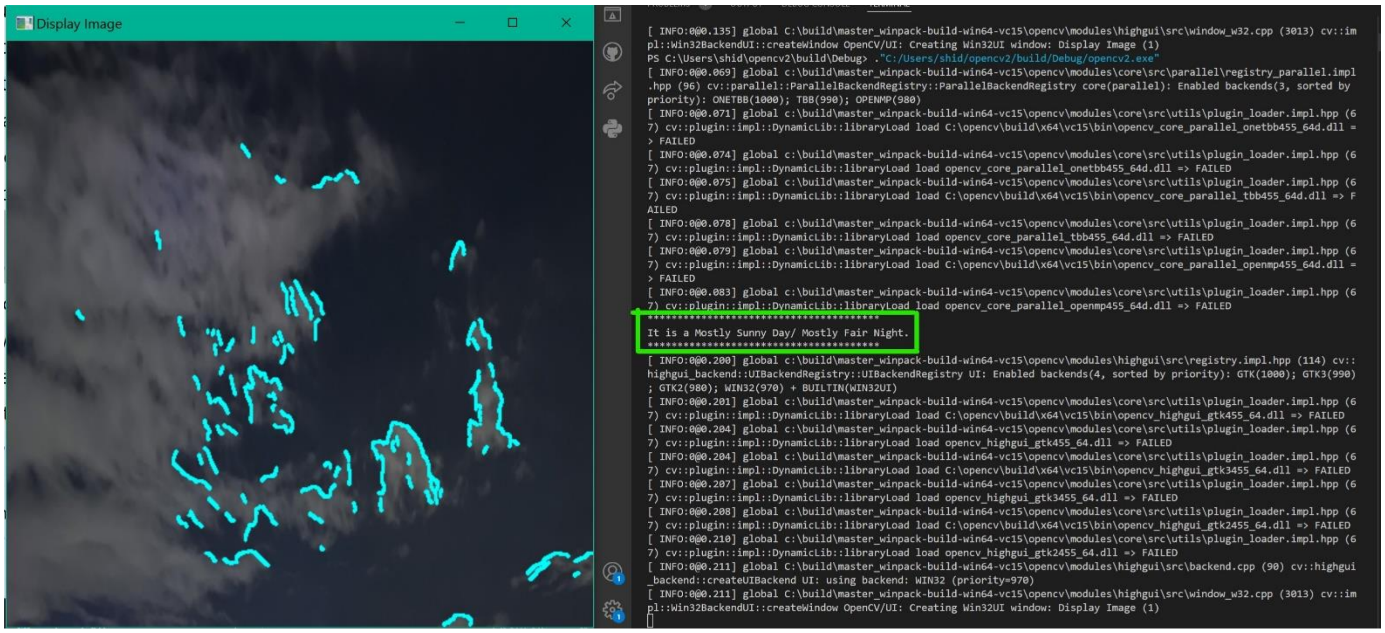


Figure 8- Raw Image



```
[ INFO:0@0.135] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
PS C:\Users\shid\opencv2\build\Debug> ."C:/Users/shid/opencv2/build/Debug/opencv2.exe"
[ INFO:0@0.069] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\parallel\registry_parallel.impl
.hpp (96) cv::parallel::ParallelBackendRegistry::ParallelBackendRegistry core(parallel): Enabled backends(3, sorted by
priority): ONETBB(1000); TBB(990); OPENMP(980)
[ INFO:0@0.071] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_onetbb455_64d.dll =
> FAILED
[ INFO:0@0.074] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.075] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.078] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.079] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.083] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
**************************************
It is a Mostly Sunny Day/ Mostly Fair Night.
**************************************
[ INFO:0@0.200] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.201] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.204] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.204] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.207] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.208] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.210] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.211] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.211] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 9- Code Output (Mostly Fair Night)

The next percentage range is 17%-40% which corresponds to a partly sunny for daytime and partly cloudy for nighttime conditions. The code's if statement for this range is 161 to 400. The 161 in percentage terms was rounded up to 17% in order to make the data digestible and easier to process. The end results for the partly sunny condition test are shown in Figures 10 and 11. Additionally, the image in Figure 10 was taken using an iPhone 12 Pro camera.

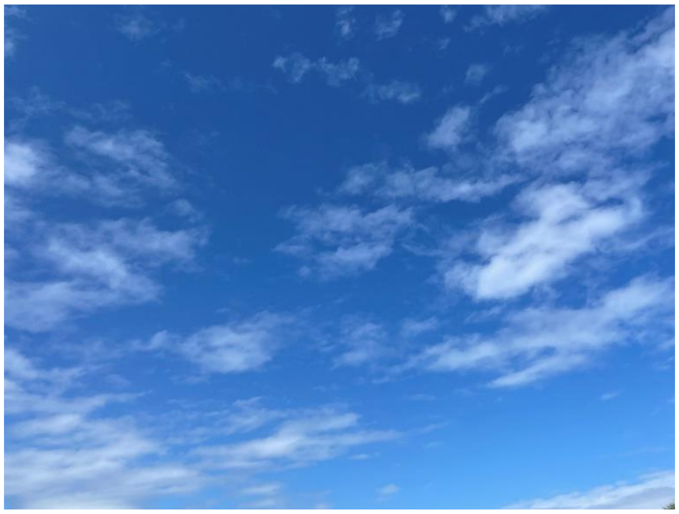
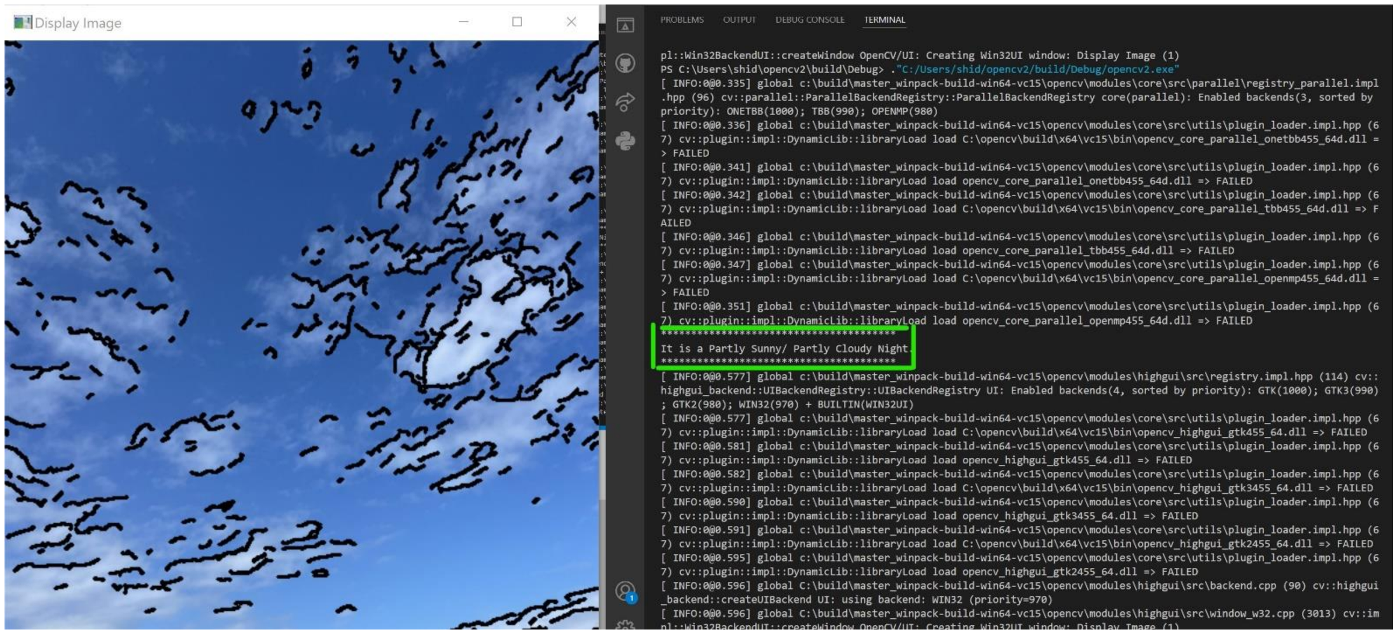


Figure 10- Raw Image



```
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
PS C:\Users\shid\opencv2\build\Debug> ."C:/Users/shid/opencv2/build/Debug/opencv2.exe"
[ INFO:0@0.335] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\parallel\registry_parallel.impl
.hpp (96) cv::parallel::ParallelBackendRegistry::ParallelBackendRegistry core(parallel): Enabled backends(3, sorted by
priority): ONETBB(1000); TBB(990); OPENMP(980)
[ INFO:0@0.336] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_onetbb455_64d.dll =
> FAILED
[ INFO:0@0.341] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.342] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.346] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.347] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.351] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
***************************************
It is a Partly Sunny/ Partly Cloudy Night.
***************************************
[ INFO:0@0.577] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.577] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.581] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.582] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.590] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.591] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.595] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.596] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.596] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 11- Code Output (Partly Sunny Day)

Figures 12 and 13 show the nighttime conditions of a partly cloudy night. They share the same contour range as the partly sunny day mentioned above. Compared to the mostly fair night from Figure 9, you can clearly see many more contour outlines in Figure 13, which accurately qualifies it to the 17%-40% input range. Although the code identified the moon as a cloud in Figure 13, there are more than enough remaining contour lines surrounding the other clouds that make up for it.

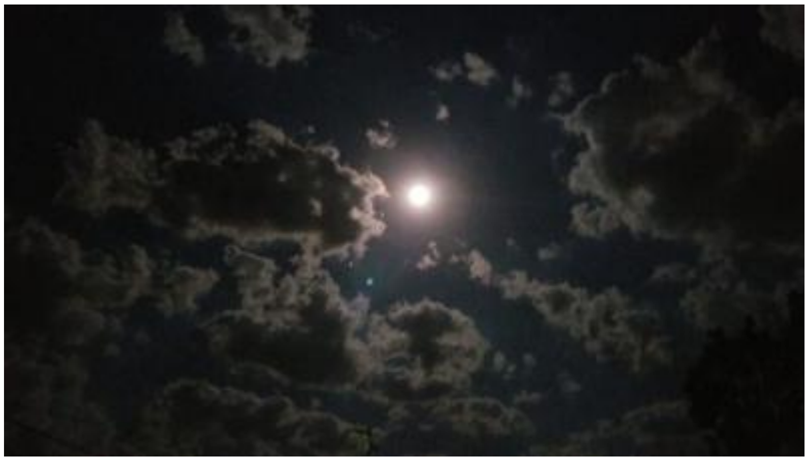
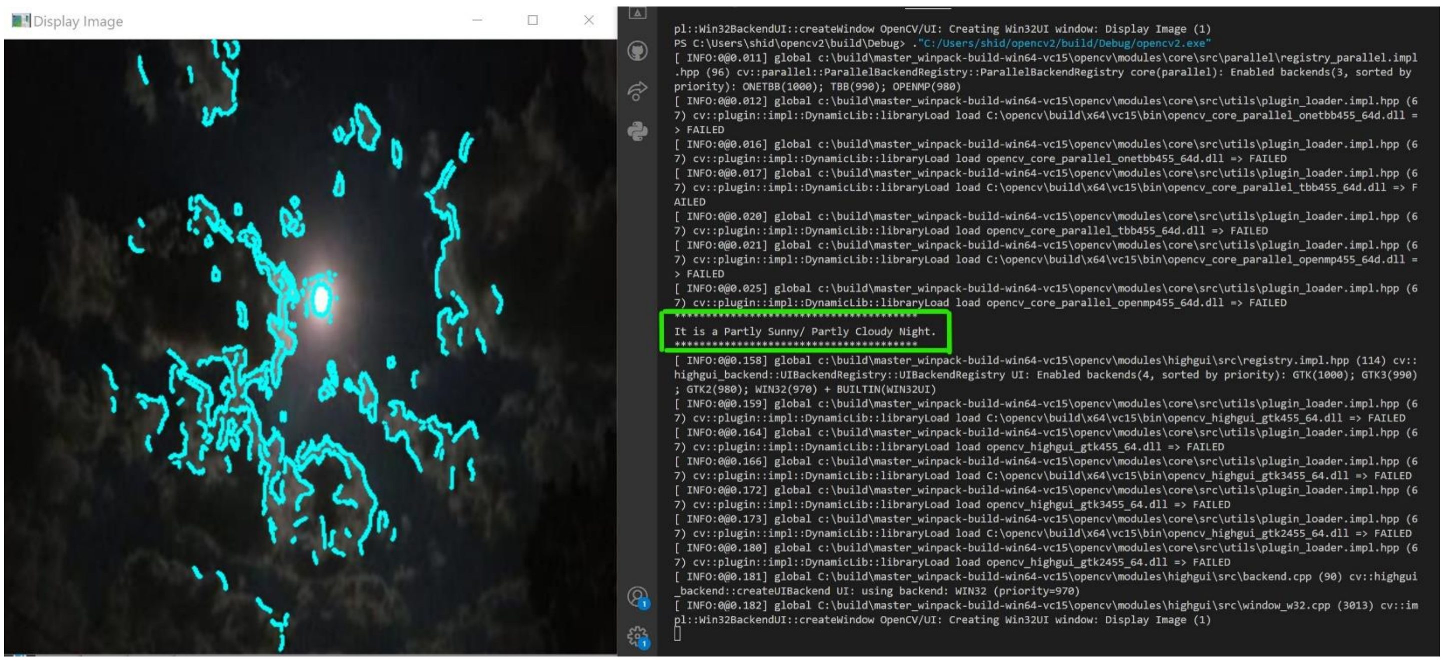


Figure 12- Raw Image



```
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
PS C:\Users\shid\opencv2\build\Debug> ."C:/Users/shid/opencv2/build/Debug/opencv2.exe"
[ INFO:0@0.011] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\parallel\registry_parallel.impl
.hpp (96) cv::parallel::ParallelBackendRegistry::ParallelBackendRegistry core(parallel): Enabled backends(3, sorted by
priority): ONETBB(1000); TBB(990); OPENMP(980)
[ INFO:0@0.012] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_onetbb455_64d.dll =
> FAILED
[ INFO:0@0.016] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.017] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.020] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.021] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.025] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
**************************************
It is a Partly Sunny/ Partly Cloudy Night.
**************************************
[ INFO:0@0.158] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.159] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.164] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.166] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.172] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.173] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.180] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.181] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.182] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 13- Code Output (Partly Cloudy Night)

The last percentage range used is 41%-100% and it corresponds to a mostly cloudy condition for both daytime and nighttime. The code’s if statement for this range is 401 to 1000. Similar to the previous range, the percentage was rounded up to 41% in order to keep the data easy to process and understand. The end results for the mostly cloudy daytime sky condition are shown in Figures 14 and 15.

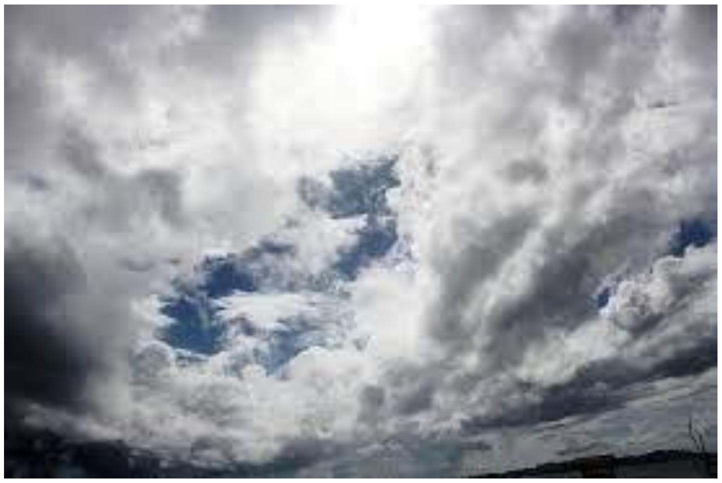
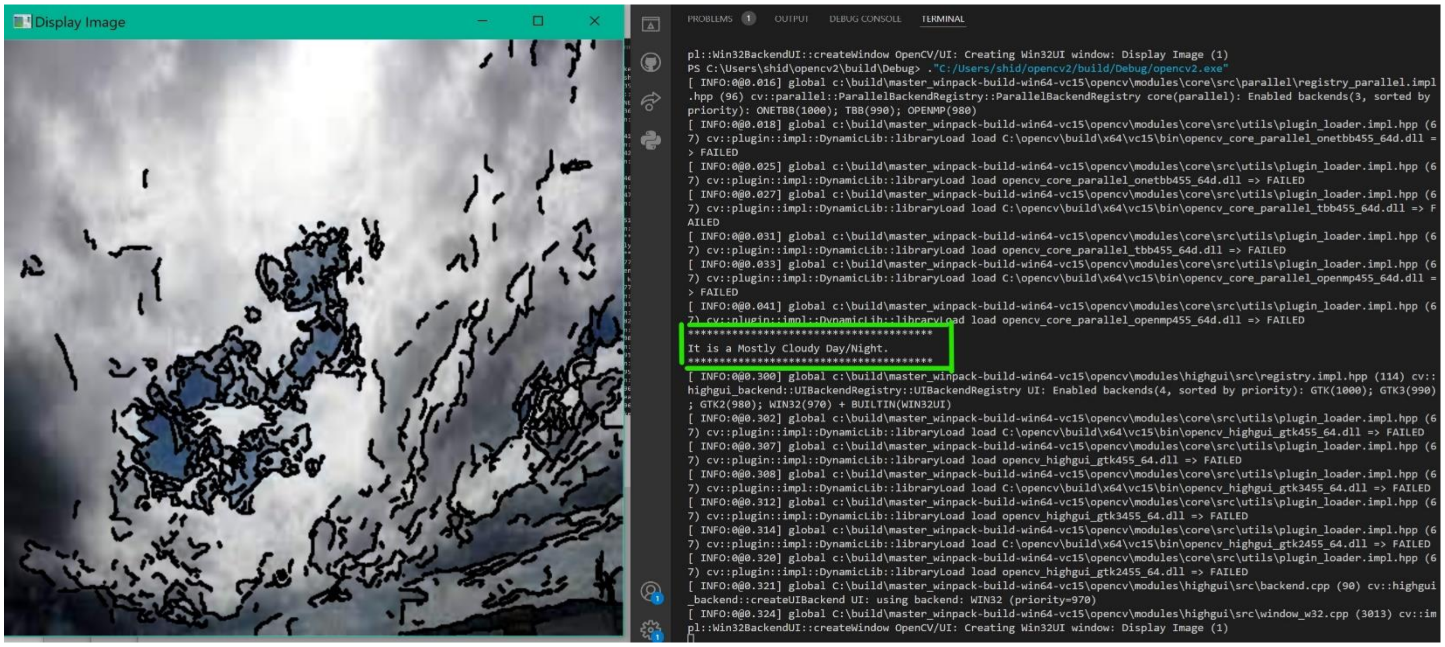


Figure 14- Raw Image



```
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
PS C:\Users\shid\opencv2\build\Debug> ."C:/Users/shid/opencv2/build/Debug/opencv2.exe"
[ INFO:0@0.016] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\parallel\registry_parallel.impl
.hpp (96) cv::parallel::ParallelBackendRegistry::ParallelBackendRegistry core(parallel): Enabled backends(3, sorted by
priority): ONETBB(1000); TBB(990); OPENMP(980)
[ INFO:0@0.018] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_onetbb455_64d.dll =
> FAILED
[ INFO:0@0.025] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.027] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.031] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.033] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.041] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
***************************************
It is a Mostly Cloudy Day/Night.
***************************************
[ INFO:0@0.300] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.302] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.307] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.308] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.312] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.314] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.320] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.321] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.324] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 15- Code Output (Mostly Cloudy Day)

Figures 16 and 17 show the nighttime conditions of a mostly cloudy night. They share the same contour range as the mostly cloudy day shown above. Compared to the partly cloudy night from Figure 13, there is a stark difference in how many more contour outlines there are in Figure 17, which accurately qualifies it to the 41%-100% input range. Furthermore, this is proof the code was successful its objective as the image in Figure 16 is visually similar to what a casual observer would call a mostly cloudy night.

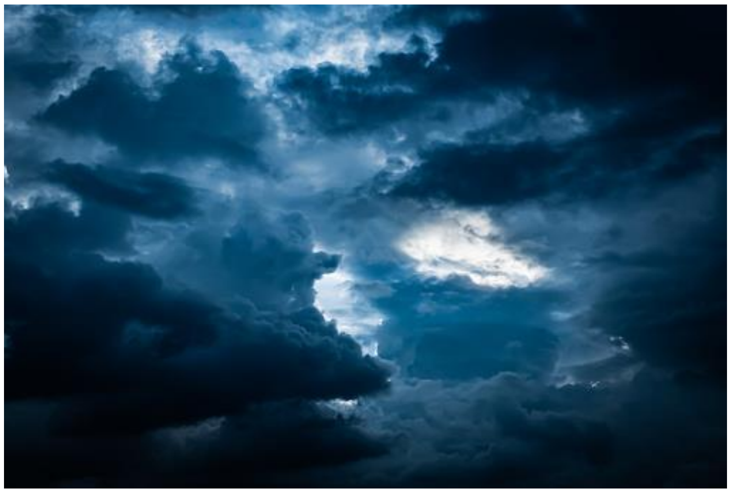
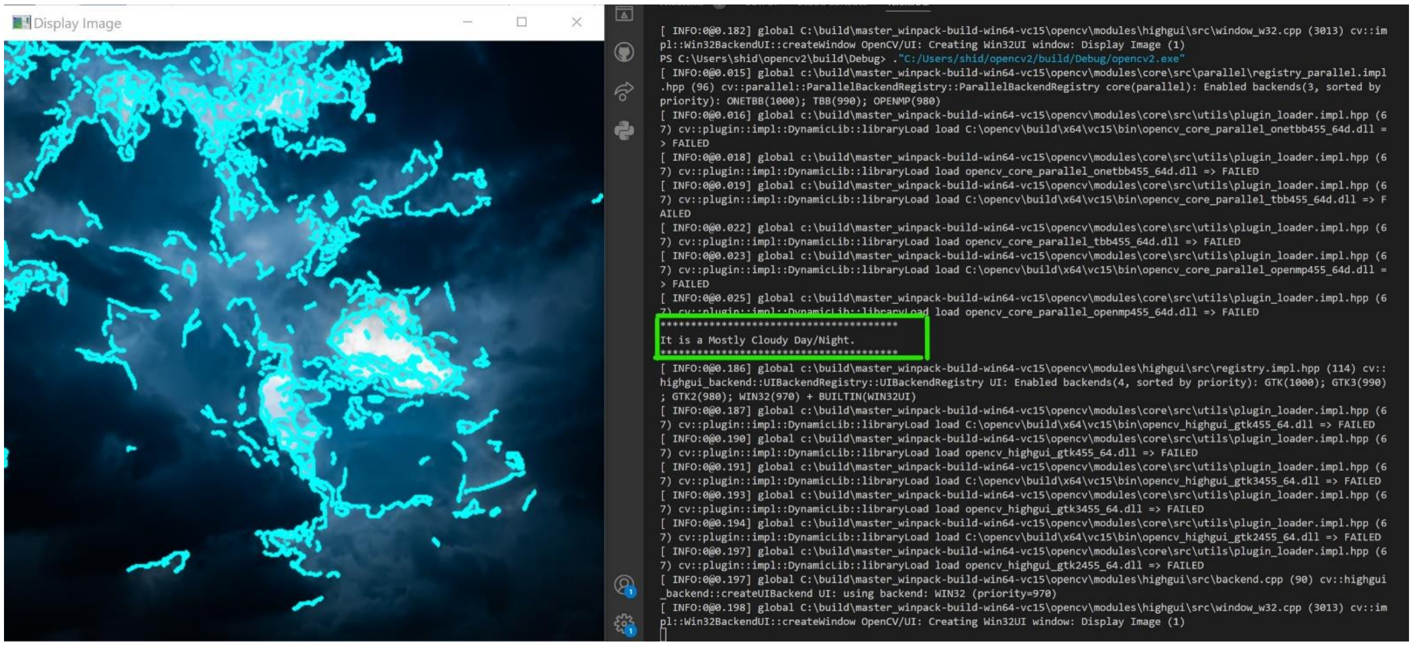


Figure 16- Raw Image



```
[ INFO:0@0.182] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
PS C:\Users\shid\opencv2\build\Debug> ."C:/Users/shid/opencv2/build/Debug/opencv2.exe"
[ INFO:0@0.015] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\parallel\registry_parallel.impl
.hpp (96) cv::parallel::ParallelBackendRegistry::ParallelBackendRegistry core(parallel): Enabled backends(3, sorted by
priority): ONETBB(1000); TBB(990); OPENMP(980)
[ INFO:0@0.016] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_onetbb455_64d.dll =
> FAILED
[ INFO:0@0.018] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_onetbb455_64d.dll => FAILED
[ INFO:0@0.019] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_tbb455_64d.dll => F
AILED
[ INFO:0@0.022] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_tbb455_64d.dll => FAILED
[ INFO:0@0.023] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_core_parallel_openmp455_64d.dll =
> FAILED
[ INFO:0@0.025] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_core_parallel_openmp455_64d.dll => FAILED
**************************************
It is a Mostly Cloudy Day/Night.
**************************************
[ INFO:0@0.186] global c:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\registry.impl.hpp (114) cv::
highgui_backend::UIBackendRegistry::UIBackendRegistry UI: Enabled backends(4, sorted by priority): GTK(1000); GTK3(990)
; GTK2(980); WIN32(970) + BUILTIN(WIN32UI)
[ INFO:0@0.187] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.190] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk455_64.dll => FAILED
[ INFO:0@0.191] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.193] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk3455_64.dll => FAILED
[ INFO:0@0.194] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load C:\opencv\build\x64\vc15\bin\opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.197] global c:\build\master_winpack-build-win64-vc15\opencv\modules\core\src\utils\plugin_loader.impl.hpp (6
7) cv::plugin::impl::DynamicLib::libraryLoad load opencv_highgui_gtk2455_64.dll => FAILED
[ INFO:0@0.197] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\backend.cpp (90) cv::highgui
_backend::createUIBackend UI: using backend: WIN32 (priority=970)
[ INFO:0@0.198] global C:\build\master_winpack-build-win64-vc15\opencv\modules\highgui\src\window_w32.cpp (3013) cv::im
pl::Win32BackendUI::createWindow OpenCV/UI: Creating Win32UI window: Display Image (1)
```

Figure 17- Code Output (Mostly Cloudy Night)

In conclusion, the program accurately and successfully fulfilled its objective. It was able to determine the sky condition by computing the sky as a percentage of cloud coverage. By adding the estimated range using the Georgia Forestry Commission’s guidelines, the program detected if the sky was sunny/clear, mostly sunny/fair, partly sunny/cloudy, and mostly cloudy whether it was daytime or nighttime.

Description of How to Compile and Run Code

This project was done using VS Code. Make sure to have VS Code, OpenCV, CMAKE and C++ installed, alongside with Code Runner as an extension in VS Code.

To compile, open the .CC file. After opening the file, input the path of the image. You can use one of the provided ones in the Image directory linked in GitHub. Then, simply hit the play button on the bottom of the screen.

Important Links

- https://github.com/snipasid/CPE462-Final-Project.git
    - Source code
    - ReadMe
    - Images
- https://windy.app/blog/what-is-cloud-cover.html
    - Information about cloud coverage
- http://weather.gfc.state.ga.us/Info/WXexp.aspx
    - Information about sky conditions percentage