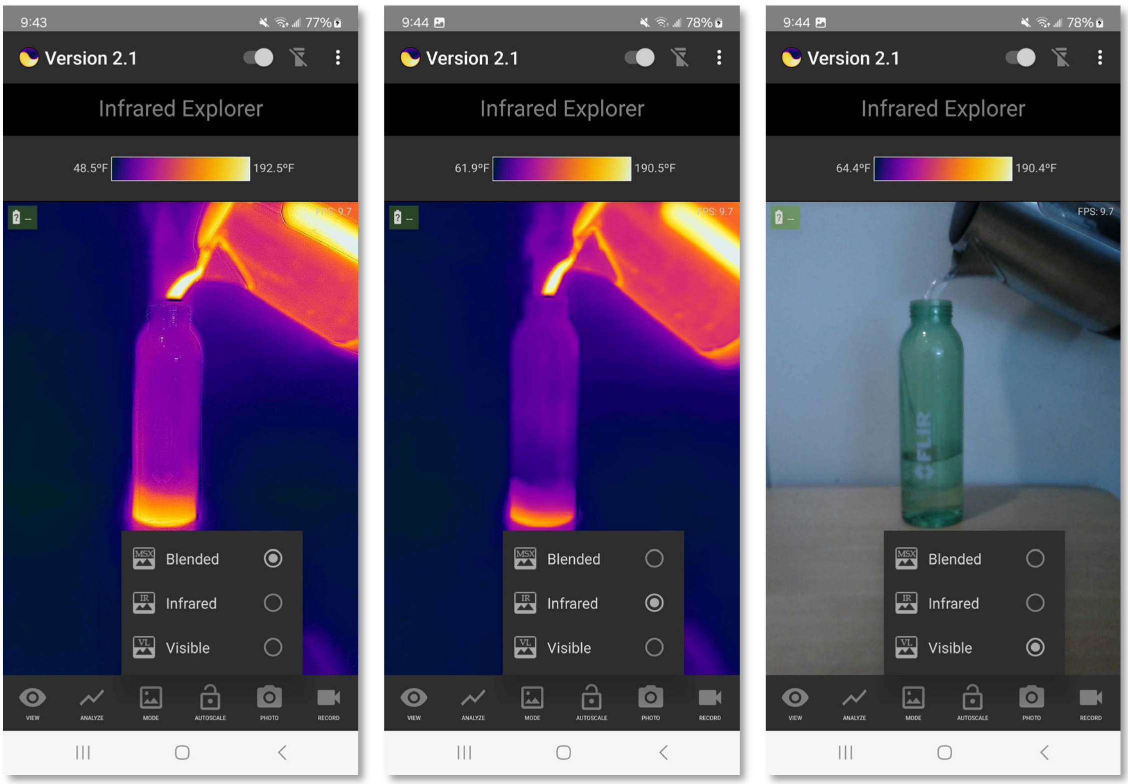
Infrared Explorer Development

2024 Annual Report to the National Science Foundation

The Infrared Explorer (IE) Version 2.0 was developed based on the latest FLIR Mobile SDK (version 2.4.0) for Android. Compared with the previous generations of SDK, this version offers a lot of improvements and enhancements. Version 2.0 and higher benefit from these recent advancements of FLIR's SDK. The IE app has many features. It is impossible to include all of them in this report. We select the following features to report, but keep in mind that the IE app has many more to offer.

Basic Imaging

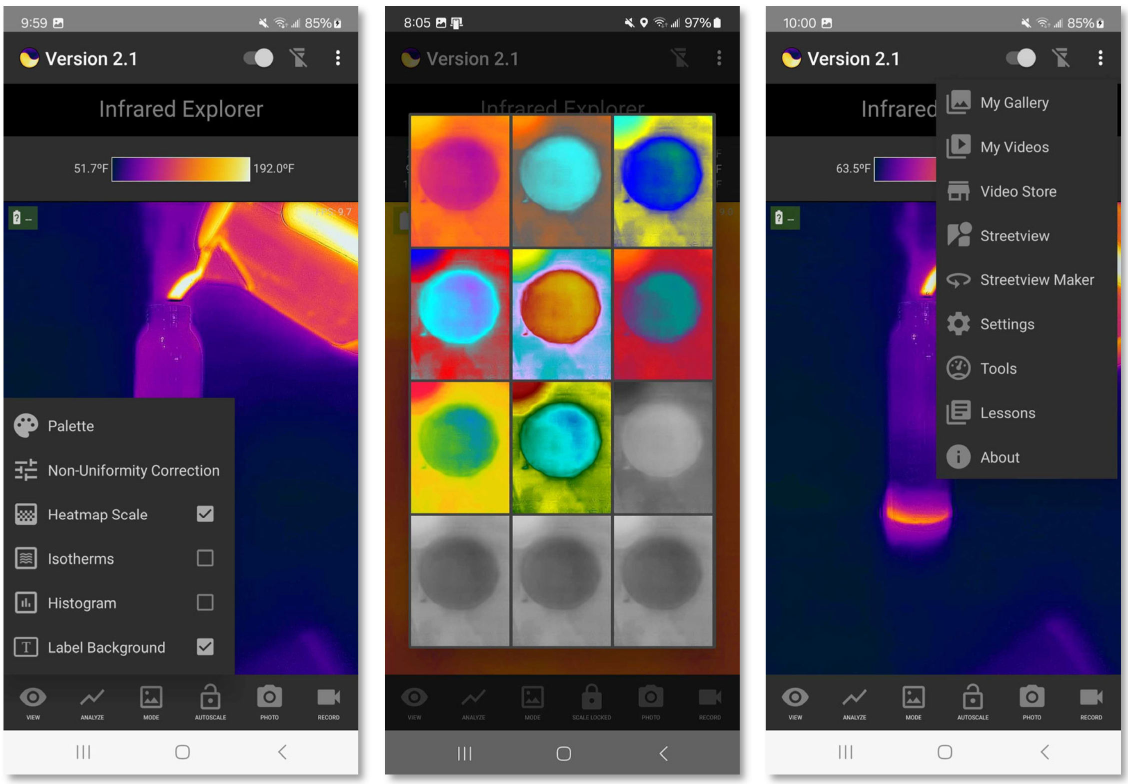
The IE app supports three modes: Infrared, Visible, and Blended (Box 1). The Infrared Mode shows purely thermal images. The Visible Mode shows conventional digital images. And the Blended Mode is based on mixing the infrared and visible light images. While the Blended Mode may be useful in many cases, we recommend that the Infrared Mode be used in science experiments as the lines in the Blended Mode may be distracting in some cases.



Box 1

The buttons at the bottom of the screen provide tools that support thermal imaging. The left one is for changing the view. When the button is tapped, a menu pops up for the user to select an option, as shown in the first image in Box 2. For example, when the user selects Palette, the IE app will show 12 coloring types for users to choose from, shown in the second image in Box 2.

The three dots button at the upper right corner of the screen provides access to other functionalities of the app, as shown in the third image in Box 2.



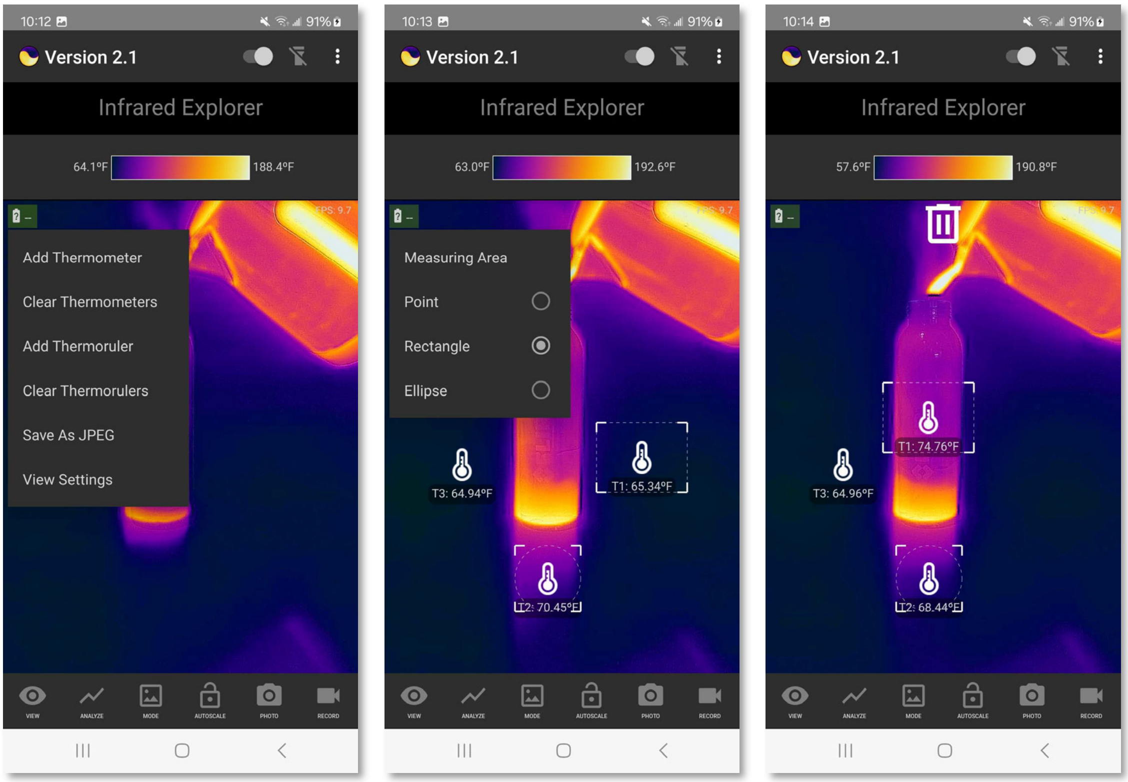
Box 2

Real-Time Analysis

Thermal images themselves do not provide quantitative results that are needed in science experiments. For further analysis, the IE app allows users to add two types of measuring tools: thermometers and thermorulers. As its name implies, the former measures the temperature of a spot just like an infrared thermometer. The latter is unique in the IE app. As its name suggests, it has the shape of a ruler that measures a series of temperature values along it.

To add a thermometer, long-press the spot on the screen where you want the thermometer to be placed, a menu will show up, from which you can select “Add Thermometer” to drop a thermometer, as shown in the first image of Box 3. A thermometer can measure the temperature of a point, the average temperature of a rectangular area, or the average temperature of an elliptical area, as shown in the second image of Box 3. To change the measuring scope of a thermometer, long-press it to open the corresponding menu. To remove a thermometer, drag it and you will see a trash bin image that shows up at the top of the screen (the third image of Box 3). Drag the thermometer into the trash bin and it will disappear.

The thermorulers work in a similar way.



Box 3

Once you add thermometers or thermorulers, you can then open the Analyze Menu by tapping the Analyze Button at the bottom of the screen (the first image in Box 4). There are two types of graphs to select. The most common type is T(t), temperature as a function of time. The other type shows the temperature distribution along a selected direction: X, Y, or R. The X and Y directions are used to show the temperature distributions in the horizontal and vertical directions, whereas the R direction is used to show the radial distribution of temperature.

When a graph is shown, long-pressing the screen opens up a menu that allows you to customize the graph, take a screenshot, change the length of the time window (i.e., for how long you would like to keep the temperature data in the graph), export the graph to a CSV file for analysis using other software, and so on, as shown in the second image in Box 4. The third image in Box 4 shows the options available for you to customize a graph.

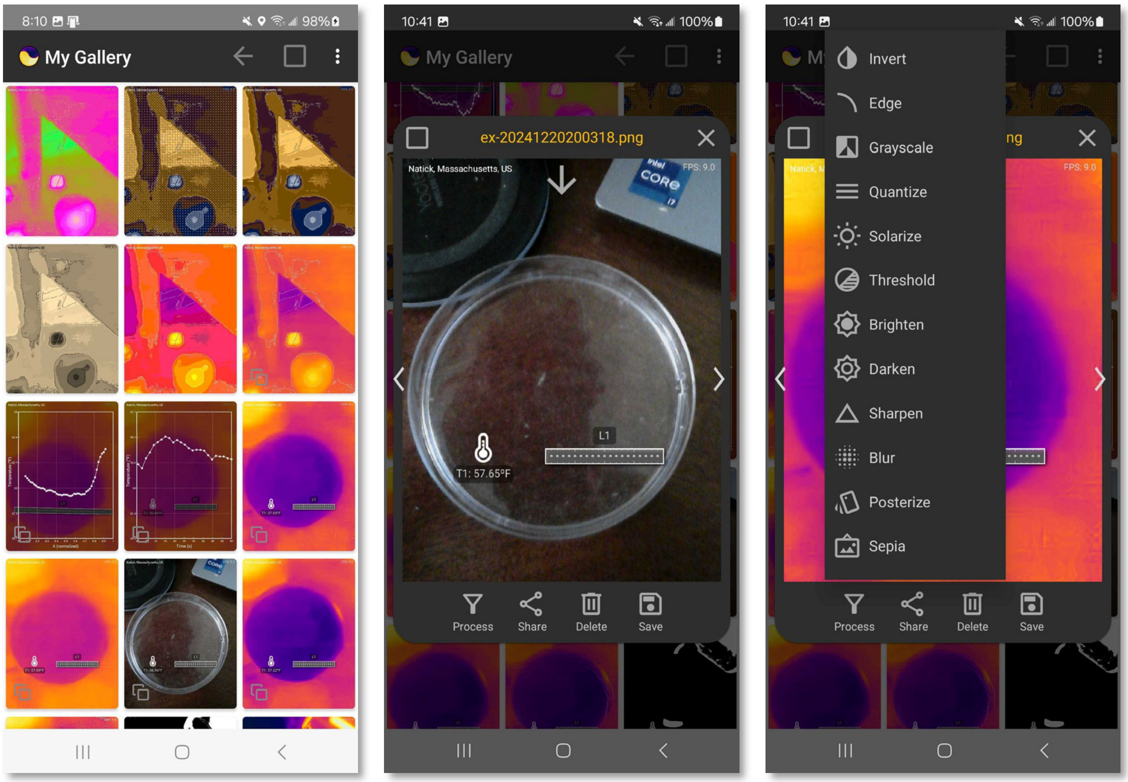
Box 4

My Gallery

Like your photo apps, the IE app allows you to capture images as records. The difference is that, when you tap the Photo Button at the bottom of the screen, two images are recorded: one is the infrared light image, and the other is the visible light image.

Captured images can be found in My Galley available from the three-dot menu (the first image in Box 5). When you tap a thumbnail image in the Gallery, a window will open that shows the selected image. Aside from the left and right arrow buttons that allow you to go to the previous or next image, the up or down arrow at the top of the image allows you to switch back and forth between the infrared light image and the visible light image (the second image in Box 5).

In image processing, filters refer to mathematical functions used to perform blurring, sharpening, embossing, edge detection, and other transformations. The IE app incorporates a set of filters for post-processing thermal images (i.e., after the images are taken). These tools are conveniently available through the Process Button on the Image Viewer provided by My Gallery, as illustrated in the third image of Box 5.



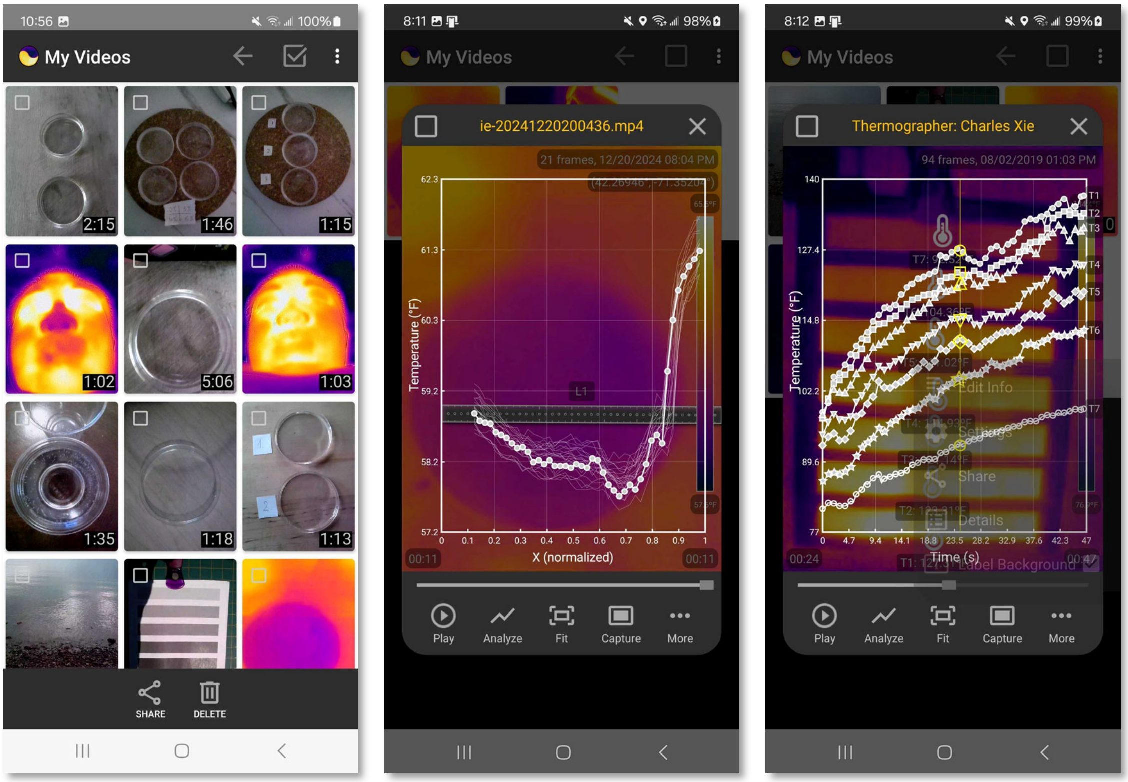
Box 5

My Videos

The IE app allows you to record an experiment or observation just like a conventional video. The difference is that a video in the IE app contains rich data for you to carry out extensive post-experiment analysis. In fact, we recommend that you record an experiment for post-analyses because analysis usually takes a lot of time whereas many experiments such as chemical reactions may last for only a short while. To record a thermal video, tap the Record Button at the bottom of the screen to start. To stop recording, tap it again.

A recorded thermal video will show up in My Videos, which can be opened from the three-dot menu. The first image in Box 6 shows My Videos, which displays all the collected videos.

Just like the real-time mode, you can add thermometers and thermorulers to these thermal videos to conduct in-depth analysis. For example, the second image in Box 6 shows the temperature as a function of X coordinate, measured by a horizontal thermoruler. This image also shows the traces, representing the changes of the spatial distribution over the recorded period. The third image shows that you can place several thermometers to measure the heating of different color strips under the sun over time. When the video is played, a vertical line will move to indicate where the current video frame is in the graph.



Box 6

Other Features

The IE app has many other features that we do not include in this report for brevity. These features include, but are not limited to, 1) Street View – a special type of video supported by the IE app that allows users to record data of geographical significance; 2) Video Stores – a collection of pre-recorded videos that anyone can download to analyze themselves; and 3) Lessons – a built-in support that allows educators to deliver in-app curriculum modules that guide students to conduct an experiment.