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1 Welcome to MTP

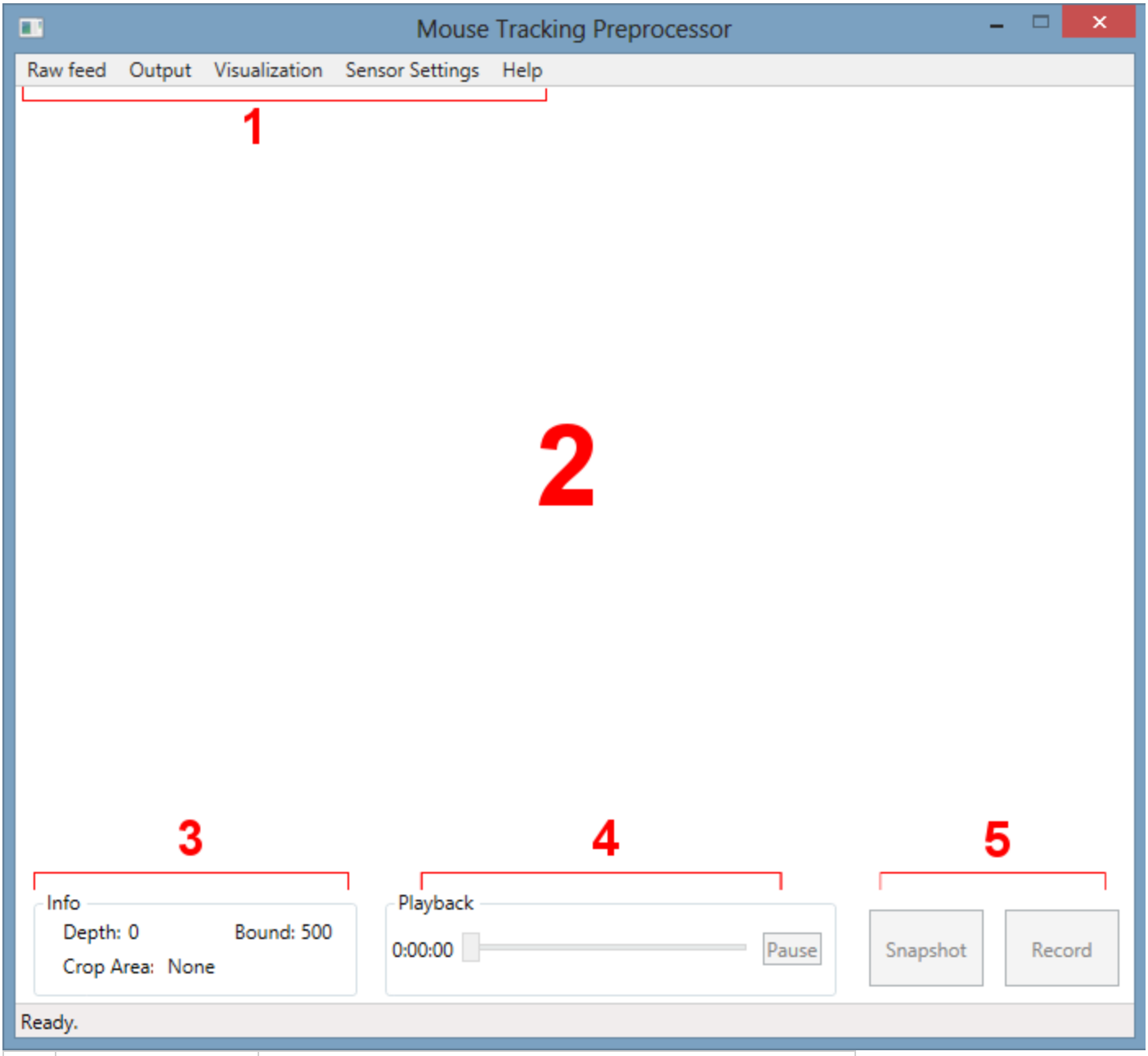
MTP is an application that allows users to visualize and capture data from TIme-of-Flight sensors for research purposes.

The application allows users to:

- Visualize and capture data from both Kinect for Windows and sensors using the Intel Perceptual Computing SDK (such as the Creative Interactive Gesture Camera).
- Record and play back raw data from sensors powered by the Intel SDK.
- Output color images, gray scale depth images, heat map depth images, mapped color-on-depth images, mapped depth-on-color images, and combined pre-processed images.
- Choose between saving scaled height from a background plane (8-bit) depth data, and absolute distance from the sensor (16-bit).
- Select a fraction of the area to be saved (reducing file size).
- Obtain help in adjusting the sensor's position through a calibration tool.
- Change sensor-specific settings such as near mode, depth smoothing, and infrared color mode.
- Save snapshots.
- Record compressed (JPEG or PNG) or uncompressed SEQ video, or PNG frames to a directory.
- Visualize data from the sensor (color, depth gray scale, depth heat map, combined pre-processed feeds) and depth values.
- Trigger actions from third-party applications, such as Matlab.

2 The MTP User Interface

The MTP user interface consists of several areas, outlined below:



1	**Toolbar**	Contains common action buttons and shortcuts to MTP views.
2	**Data visualization**	Displays data from the currently active sensor.
3	**Image information**	Displays useful information about the currently shown image.
4	**Playback info**	Displays information on the playback of raw data.

5	**Data acquisition**	Contains data acquisition controls.

3 The SEQ File Format

When recording to file(s), data can be saved in SEQ file format. This format is based on the Norpix SEQ format.

Uncompressed SEQ files

The format used to save uncompressed SEQ files matches the format described in Norpix's SEQ specification, where a 1024 header is followed by frames one after another, and each frame is it's raw data (of size specified in the header), followed by a time stamp (Int32 time_t, UInt16 milliseconds, UInt16 microseconds).

In particular, MTP uses the following format IDs for the CImageInfo.ImageFormat field:

- **000**: Unknown uncompressed format.
- **100**: Monochrome (1 channel) uncompressed format.
- **200**: BGR (3 channel) uncompressed format.
- **500**: BGRA (4 channel) uncompressed format.

Compressed SEQ files

MTP can save JPEG and PNG compressed SEQ files. Since no public specification is available, the format used might not match the one used by Norpix exactly. Instead, the format used was designed to match the one accepted by Piotr Dollar's Matlab Toolbox, with very small changes.

In this format, two files are stored: an SEQ file where all the frame data is saved, and a MAT file where a n_frames*1 MATLAB array containing, for each frame, its corresponding starting byte in the SEQ file (UInt64), is stored.

Compressed SEQ files look like this:

1. 1024 byte header;
2. Frames, where each frame is:
    - (UInt32) Size of current frame in bytes, including the final timestamp but excluding this image size value;
    - Frame data, using either PNG or JPEG compression;
    - Time stamp as follows: Int32 time_t, UInt16 milliseconds.

Note that the file header includes the format of the image being stored (CImageInfo.ImageFormat). For compressed files, a compression identifier (**2** for JPEG, **3** for PNG) is added to the uncompressed ID. Note that this differs slightly from Piotr Dollar's Toolbox interpretation at the time of writing, and results in the following table:

- **002**: Unknown JPEG compressed format.
- **003**: Unknown PNG compressed format.
- **102**: Monochrome (1 channel) JPEG compressed format.
- **103**: Monochrome (1 channel) PNG compressed format.
- **202**: BGR (3 channel) JPEG compressed format.
- **203**: BGR (3 channel) PNG compressed format.
- **502**: BGRA (4 channel) JPEG compressed format.
- **503**: BGRA (4 channel) PNG compressed format.

4 Getting Started

4.1 Enabling a Sensor

The first step in using the program is selecting a raw feed for data visualization. Using the Raw feed menu on the toolbar, you can choose a sensor and mode for data acquisition. Before selecting a feed, make sure that the sensor is connected, installed, and ready for use.

Once a raw feed is started, the rest of the user interface is enabled and data can be processed. Any settings changed after this point are saved between executions. The *Playback* section of the user interface displays the elapsed since the sensor was enabled. If **Intel Playback** was selected, the section also allows seeking and pausing.

To disable the currently enabled sensor, select **None** from the Raw feed menu.

Enabling a sensor

- In order to use data from a Kinect for Windows sensor, select **Kinect**. This will activate the first identified Kinect sensor connected to the computer.
- In order to use data from an Intel Perceptual Computing sensor, select one of the following options.
    - **Intel Stream** acquires data from a real sensor without saving it in raw format. Use this option to save processed data in real time.
    - **Intel Record** acquires data from a real sensor, while simultaneously saving in raw format to the */videos* folder. Use this option to save raw data to be processed at a later time.
    - **Intel Playback** acquires data from a virtual sensor created from a previously recorded file. Use this option to process previously saved raw data.

Disabling a sensor

To disable the currently enabled sensor, select **None** from the Raw feed menu.

4.2 Configuring a Sensor

Once a sensor has been enabled and is streaming data, some settings can be configured.

Use the Sensor settings menu item on the toolbar to configure sensor-specific settings, configure processing parameters, and access the sensor calibration tool.

By clicking a point on the visualized image, the depth of that point is saved as background depth (shown in the *Image Information* section of the user interface).

4.3 Visualizing Data

Data acquired by the sensor can be processed and displayed in MTP.

Use the Visualization menu item on the toolbar to select the displaying method for the streaming data. Use the Sensor settings **-> Processing parameters...** view to configure the sensor's processing parameters.

4.4 Capturing Data

Data acquired by the sensor can be processed and saved to file(s) by MTP.

The images seen in the *Data visualization* section of the user interface reflect the data that will be saved to file(s). Use the Visualization menu item on the toolbar to select the displaying method for the streaming data. Use the Sensor settings **-> Processing parameters...** view to configure the sensor's processing parameters. Click on a point on the visualized image to quickly change the background threshold to that point's depth.

Capturing Snapshots

1. Select one or more output modes using the Output menu item on the toolbar.
2. Optionally select a crop area using the Output **-> Crop area** feature. Once this option is selected, the region of the image to be saved can be selected by modifying the size of the blue square on the image. Note that this area must be changed for both color and depth feeds (if they're both being saved) by switching between views using the Visualization menu item. The top left point and size of the selected crop area in the current view is displayed in the *Image information* section of the user interface.
3. Press the **Snapshot** button in the *Data acquisition* section of the user interface to save the selected images to the */images* folder.

Recording Video

1. Select one or more output modes using the Output menu item on the toolbar.
2. Optionally configure recording parameters, such as image compression and video format, using the Output **-> Recording parameters...** view.
3. Optionally select a crop area using the Output **-> Crop area** feature. Once this option is selected, the region of the image to be saved can be selected by modifying the size of the blue square on the image. Note that this area must be changed for both color and depth feeds (if they're both being saved) by switching between views using the Visualization menu item. The top left point and size of the selected crop area in the current view is displayed in the *Image information* section of the user interface.
4. Press the **Record** button in the *Data acquisition* section of the user interface to start recording. The pressed button now displays the elapsed time since recording was started.
5. Press the button showing the elapsed recording time again to stop recording. The file(s) are saved to the */videos* folder.

Names of Output Files

Snapshots and recordings output from the MTP application are saved using the following file name format:

MTPType_yyyyMMdd_HH-mm-ss_feed,

where Type is the output type (Snapshot or Video), feed is the data feed being used (color, depth, ...), yyyy is the year, MM is the month, dd is the day, HH is the hour (in 24-hour format), mm is the minute, ss is the second.
Additionally, when recording SEQ files a compression identification suffix is appended to the file name: "raw" indicates no

compression, "PNG" indicates PNG compression, "Jxxx" indicates JPEG compression, where xxx is a 2-digit, 0-padded integer describing the compression quality (1-100). Compression settings can be changed through the Recording Parameters view.

When saving recordings in Frames Mode, a folder with the above name is created, and the frames within are named

MTPFrame-#########,

where # indicates the sequence number of the frame, in a 9-digit, 0-padded integer number.

4.5 Triggering from Third Party Applications

Third party applications can trigger actions within MTP. You are still expected to fire up the GUI manually, configuring the streams and double checking any settings within the native interface.

Actions can be triggered in two ways:

- The corresponding command-line tool can be launched. The tool will immediately cause its associated action to be executed, and then exit. The available command line tools are:
  - **MTPStartRec.exe**: start recording.
  - **MTPStopRec.exe**: stop recording.
  - **MTPStartStopRec.exe**: start/stop recording.
- A command can be sent over a named pipe ("MTPPipe"). Pipes can be opened at the beginning of a script and left open indefinitely, or they can be opened and closed before and after each command. The available commands are shown in the following list, and are terminated by a new line character ("/n"):
  - **s**: start recording.
  - **t**: stop recording.
  - **r**: start/stop recording.

Triggering an Action from Matlab

As an example, to execute a start/stop command in Matlab, you can use the following code:

Triggering Code

```
# Named pipe initialization; must be done sometime before using it.
NET.addAssembly('System.Core'); # import necessary .NET assembly
pipeStream = System.IO.Pipes.NamedPipeClientStream('MTPPipe'); # create pipe
pipeStream.Connect(); # connect to named pipe
writer = System.IO.StreamWriter(pipeStream); # create stream writer
# Named pipe command transmission.
writer.WriteLine('s'); # start/stop recording command
writer.Flush(); # transmit buffer
# Named pipe finalization; to be done when done using pipe.
pipeStream.Close();
```

5 Menus

5.1 Raw Feed

Use the *Raw feed* menu item to enable or disable a sensor. The following options are available:

- **Kinect**: enable the first identified Kinect sensor connected to the computer.
- **Intel stream**: enable the first identified Intel Perceptual Computing sensor connected to the computer in streaming mode. This mode lets you visualize, process, and save data, but does not automatically saved data in raw format. This is the option most frequently used.
- **Intel record**: enable the first identified Intel Perceptual Computing sensor connected to the computer in record mode. This mode lets you visualize, process, and save data, but at the same time automatically records raw data from the sensor to a **.mtp* file in the */videos* directory. This is a resource intensive process that should only be selected when raw data is desired for post-processing.
- **Intel playback**: play back previously recorded raw data, saved in a **.mtp* file. This mode lets you visualize, process, and save data out of a previously recorded raw file.
- **None**: disable the currently enabled sensor. Selected by default when the application is launched.

Note that any used sensor should be installed, available, and ready for use before selecting any of these feeds.

5.2 Output

Use the *Output* menu item to configure the result of capturing data with the application.

In this menu, one or more feeds can be saved for saving. By default, none are selected. The available feeds are:

- **Color**: save images obtained from the color sensor of the device. Unless the *Grayscale color* setting is selected, data is saved in RGB.
- **Depth Grayscale**: save data obtained from the depth sensor of the device, visualized as a gray scale image where different shades of gray indicate different depths. Unless the *16bps RGBA & Depth grayscale* setting is selected, 255 mm of depth are encoded starting at the configured background depth bound (visualized in *Image information* section of the user interface), with values behind it saved as 0 (black) and values closer than this range saved as 255 (white).
- **Depth Heatmap**: save data obtained from the depth sensor of the device, visualized as a heat map where warmer colors indicate points closer to the sensor. The coldest point is at the background, and values wrap around after the useful range is used.
- **RGBA Color-on-Depth**: save data obtained from both the depth sensor and the color sensor, with color data mapped onto a depth grayscale image (both feeds created as described above).
- **RGBA Depth-on-Color**: save data obtained from both the depth sensor and the color sensor, with depth grayscale data mapped onto a color image (both feeds created as described above).
- **Combo**: save pre-processed data, where objects closer to the sensor than the background minus the object height configured in the Processing Parameters view are highlighted. If the *Separate BW* option is selected in the Sensor Settings menu, black objects are separated from white objects according to the *Black/White threshold* option in the Processing Parameters view.

Additionally, output settings are configured from this menu. The following options are available:

- **16bps RGBA & Depth Grayscale**: save true depth instead of scaled depth in the *Depth Grayscale* and *RGBA* feeds.

When the option is selected, depth is saved as a 16-bit value in mm from the sensor. Default: disabled.

- **Grayscale Color**: save gray scale color data. When the option is selected, the *Color* feed is saved as a grayscale (1-channel monochrome) image instead of a RGB image. Default: disabled.
- **Crop Area**: enable output image cropping. Select this option to reduce the area of the image to be saved. Once this option is selected, the region of the image to be saved can be selected by modifying the size of the blue square on the image. Note that this area must be changed for both color and depth feeds (if they're both being saved) by switching between views using the Visualization menu item. The top left point and size of the selected crop area in the current view is displayed in the *Image information* section of the user interface. Default: disabled.
- **Recording Parameters...**: open the Recording Parameters view to change further recording parameters, such as number of frames to skip and compression settings.

5.3 Visualization

Use the *Visualization* menu to choose how data is to be visualized in the *Data visualization* region of the user interface. The following options are available:

- **Color**: visualize images obtained from the color sensor of the device, in RGB. Default.
- **Depth Grayscale (Scaled)**: visualized data obtained from the depth sensor of the device, visualized as a gray scale image where different shades of gray indicate different depths. 255 mm of depth are encoded starting at the configured background depth bound (visualized in *Image information* section of the user interface), with values behind it shown black and values closer than this range displayed white.
- **Depth Heatmap (Scaled)**: save data obtained from the depth sensor of the device, visualized as a heat map where warmer colors indicate points closer to the sensor. The coldest point is at the background, and values wrap around after the useful range is used.
- **Combo**: visualize pre-processed data, where objects closer to the sensor than the background minus the object height configured in the Processing Parameters view are highlighted. If the *Separate BW* option is selected in the Sensor Settings menu, black objects are separated from white objects according to the *Black/White threshold* option in the Processing Parameters view.

5.4 Sensor Settings

Use the *Sensor Settings* menu item to configure the sensor and how data is processed.

The following sensor-specific settings are available:

- **Near mode**: select to set up the sensor for a research environment, where the useful range is closer to the sensor than a standard gaming environment. Kinect only. Default: enabled.
- **Infrared**: select to set up the color camera to record in infrared mode. Kinect only. Default: disabled.
- **Separate BW**: select to separate black object from white objects when processing the *Combo* feed for visualization or output. Default: disabled.
- **Depth smoothing**: select to enable smoothing (noise reduction) of the data acquired by the depth sensor in the device. Intel Perceptual Computing only. Default: enabled.

Additionally, other settings are configured from this menu. The settings are:

- **Processing parameters...**: opens the Processing Parameters view to change further settings, such as background depth.
- **Calibration mode**: select to enable calibration of the sensor. In calibration mode four points are displayed on the image, with their depths. Additionally, the gradients between pairs of points (left-right and top-bottom) are displayed. This allows you to position the sensor parallel to the background surface, such that the two gradients

are as close to zero as possible.

5.5 Help

Use the *Help* menu to access information about the application.

6 Views

The *Recording Parameters* view allows you to configure how data will be saved to files when recording. The following settings are available:

- **Skip frames**: enter the number of frames to be skipped per every frame recorded. Use this feature when a frame rate lower than the one output by the sensor is desired, or when using slower computers.
- **Grayscale color**: select the channels used to create a gray scale image. Use this feature when recording under red light to create a more accurate gray scale image. The following settings are available:
  - **RGB**: regular gray scale image, created from a combination of all three color channels. Default.
  - **Red only**: gray scale image created from the red color channel only.
- **Mode**: select the file saving method to be used when recording data. The following options are available:
  - **SEQ**: save recordings to SEQ files in the */videos* directory, using the format specified in The SEQ File Format and the compression specified below.
  - **Frames**: save each frame of the recording separately to a PNG-compressed sequential image, to a sub-directory of */videos*.
- **Compression (SEQ)**: select the compression method to be used when saving recordings to SEQ files. The following options are available:
  - **Raw**: no compression. SEQ files match Norpix's SEQ specification. Default.
  - **PNG**: compress each frame within the SEQ file in PNG. The structure of the file matches that of Piotr Dollar's SEQ files.
  - **JPEG**: compress each frame within the SEQ file in JPEG. The structure of the file matches that of Piotr Dollar's SEQ files. The compression quality can be modified below.
- **JPEG Quality**: enter the quality used for SEQ JPEG compression, in an integer number between 1 and 100, where 100 is maximum quality (minimum compression, largest file size). Default: 80.

6.2 Processing Parameters

The *Processing Parameters* view allows you to configure how data output from Time-of-Flight sensors is processed. The following settings are available:

- **Object height**: enter the height in millimeters of the objects being tracked. When displaying and/or saving the *Combo* feed, points with a distance from the sensor less than the background minus this height are highlighted.
- **Black/White threshold**: enter the intensity threshold to distinguish black objects from white objects. When displaying and/or saving the *Combo* feed with *Separate BW* enabled (Sensor Settings), points part of an object being tracked with a gray scale intensity value above the threshold are colored red, while similar points with intensity values below the threshold are colored green.
- **Background depth**: enter the distance of the background from the sensor in millimeters. When saving 8-bit depth data, points further away from the sensor than this distance are saved as 0 (black), points between this distance and this distance minus 255 mm are mapped to a value 0-255, and points closer than this distance minus 255 mm are saved as 255 (white). Changing this value has the same effect of clicking a point at this depth in the *Data visualization* region of The MTP User Interface.