DMapLE for Android

Version 1.0 User Guide

This is not meant as a guide or introduction to diameter mapping. For this we can recommend the *Further reading* at the end of this guide.

Opening screen

The app opens with a live feed of the camera's field of view (FOV), overlaid with buttons and a ruler.

Ruler. For spatially calibrating the maps (see *Ruler*, below).

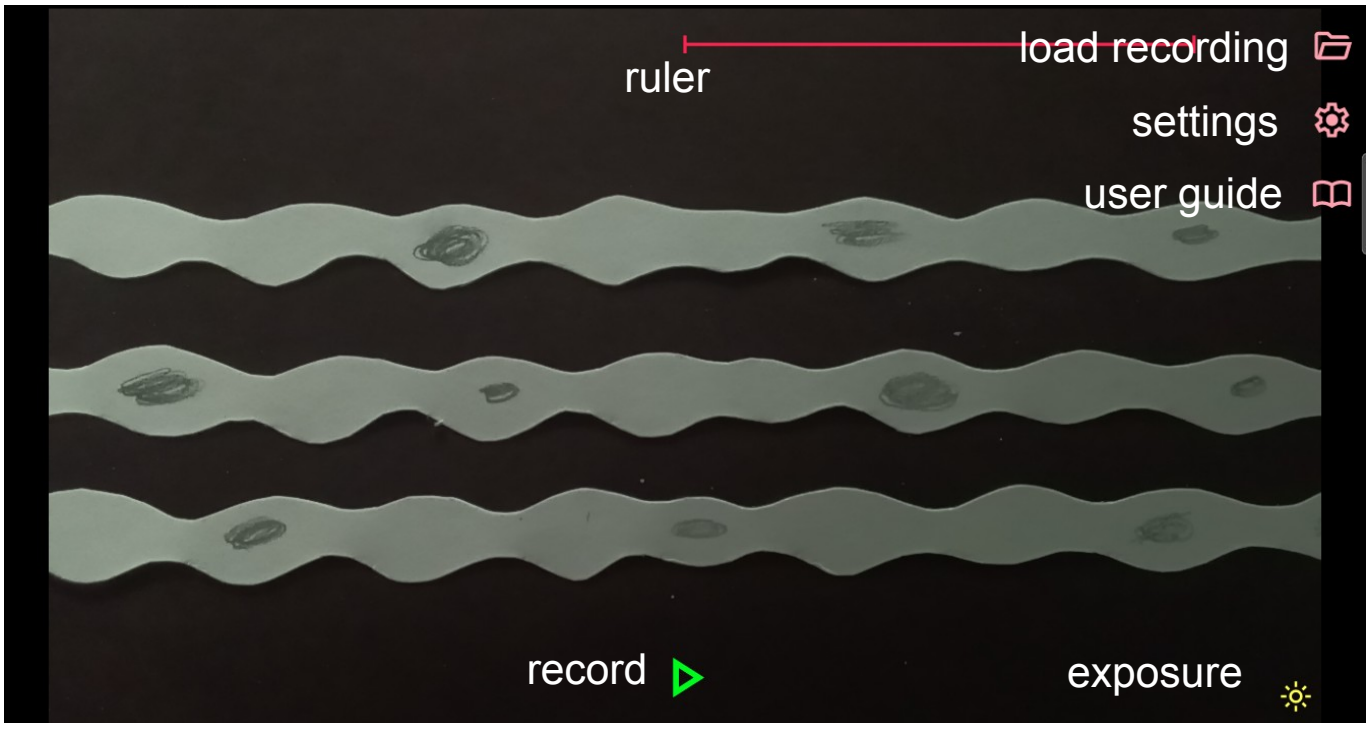
Load recording button. Load previously recorded maps and ROIs (see *Loading old recordings*).

Settings button. Open a setting page where you can adjust screen and mapping parameters (see *Settings*).

User guide button. View this user guide in your tablet's default PDF viewer.

Record button. Start recording maps (see below).

Exposure button. Open a slider to adjust the camera exposure (see *Thresholding and exposure*).



Create mapping regions of interest (ROIs)

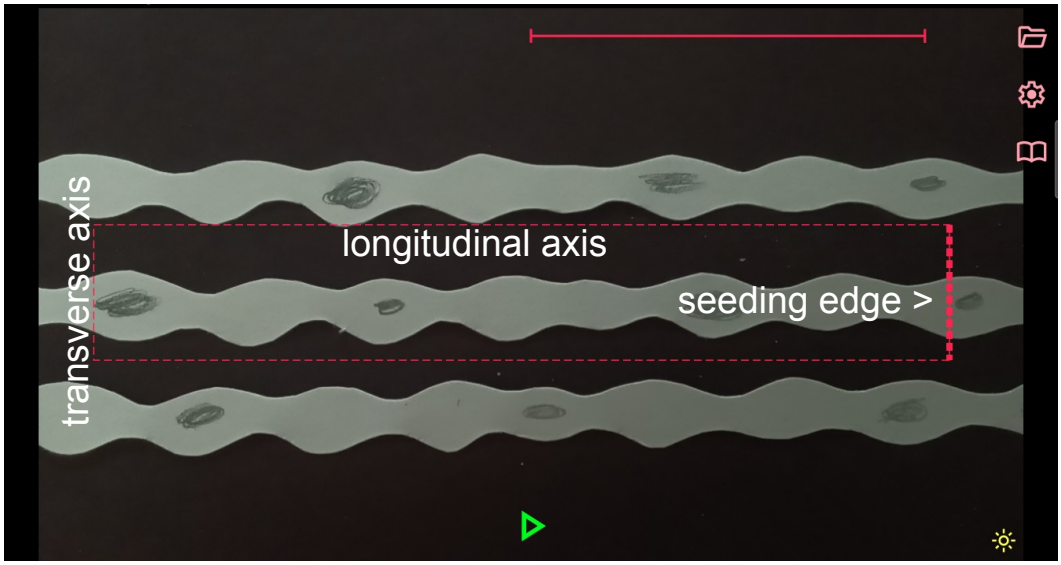
Rectangular regions of interest (ROIs) are drawn on the FOV to define lengths of gut that are to be mapped:

1) Double-tap anywhere on the FOV. An ROI appears as a red square centred on the tap.

2) With your finger on the centre of the ROI, drag to move the ROI about the FOV.

3) With your finger on an edge or corner of the ROI, drag to move that edge or corner, enlarging or contracting the ROI. Adjust the ROI until it covers the length (*longitudinal axis*) of gut you want to map.

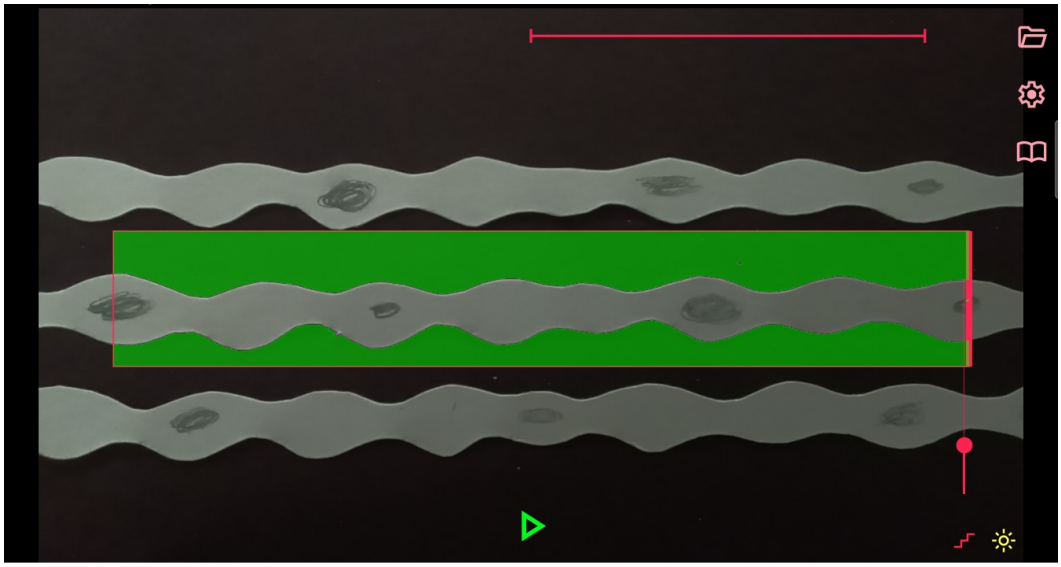
4) At at least one edge of the ROI, the “seeding edge”, must traverse the width (*transverse axis*) of the gut so that the mapping algorithm can detect the gut. Keep your finger pressed down on this edge and the edge’s line becomes thicker. The seeding edge should not touch or cross any other gut.



Thresholding and exposure

You may have noticed that when the ROI first appeared a red staircase icon appeared at the bottom of the FOV. Tap on the icon and a slider appears. This is used to set the pixel brightness threshold that the mapping algorithm uses to distinguish the gut from the background.

When you move the slider, the camera feed freezes and below threshold pixels are overlaid in green. Adjust the slider/threshold until the green defines the edges of the gut. If your gut is dark against a light background, go to the setting page and select threshold inversion (see *Settings*, below). Once you have set the threshold you can (if you wish) hide the slider by again tapping on the staircase icon.



You can tap on the sunshine icon to adjust the camera exposure. Note that the change in brightness that you actually see may depend on the specific camera, the current lighting, and the frame rate you have selected in the *Settings* (see below). After adjusting exposure, make sure the re-adjust the threshold.

Naming and map types

Now you have set the length of the gut you wish to map and the threshold which distinguishes it from the background, you should set the types of maps you want to create.

Keep your finger pressed down (long press) within the ROI. A dialog appears from which you set:

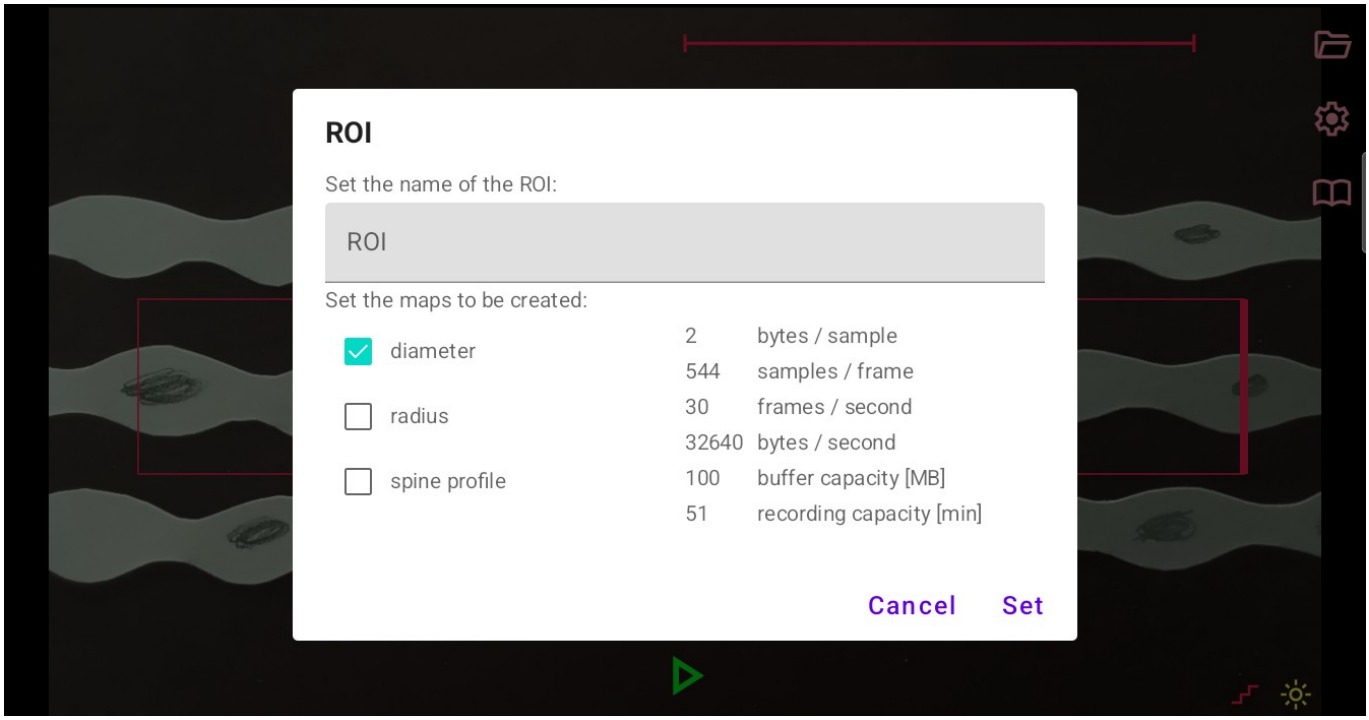
1) Which types of map to create. These are:

Diameter. The transverse distance between the edges of the gut is measured. This is the “classical”, and still most common, map type.

Radius. The mapping algorithm calculates the gut’s *spine* – the mid-point between the edges of the gut along its length. The distances (radii) from the spine to either edge of the gut are thus equal. However in settings (see below) you can set the spine to be smoothed such that the radii will be unequal and will measure asymmetric contractions on either edge, such as occur in the rabbit colon. Two maps are made, of the lower and upper edge radii.

Spine profile. The brightness (greyscale values) of the pixels on the spine itself. This map can be used for tracking pellets.

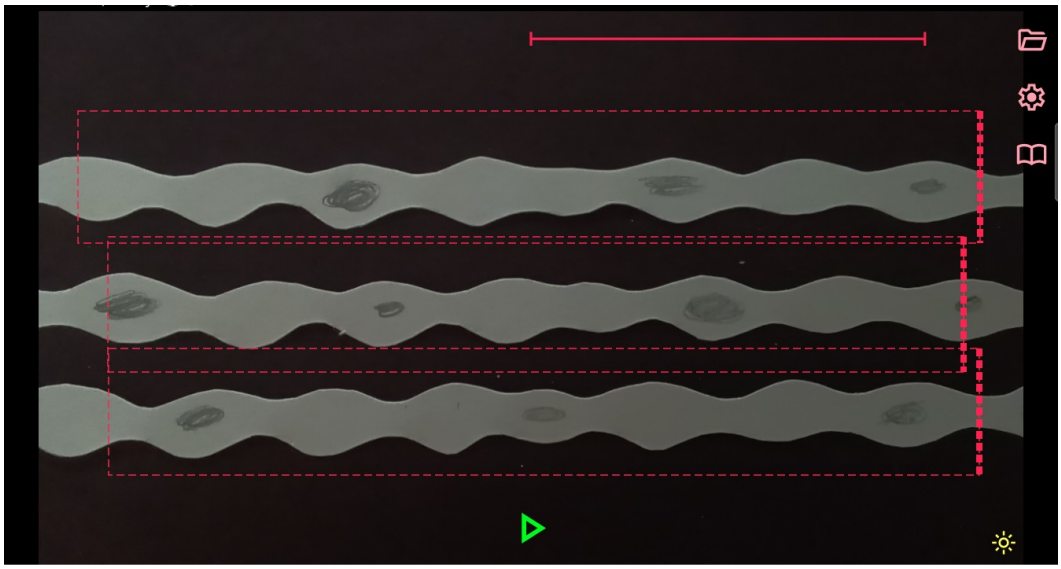
2) A name for the ROI. This name will appear at start of each map’s image file, followed by the map type. You might want to use something descriptive like “colon_proximal”. If you do not provide a name the ROIs will be named ROI_1, ROI_2,.. etc. Note non-alphanumeric characters are replaced automatically by underscores.



Each map is initially recorded into a memory buffer with a pre-defined capacity of 100 MB. This capacity typically gives an hour’s worth of recording but the exact value depends on a number of factors which are summarised at the right of the dialog. The last item in this summary is an estimate of the maximum recording length (“capacity”) in minutes. If this is too short you should reduce the spatial or temporal resolution of mapping in the *Settings* (see below).

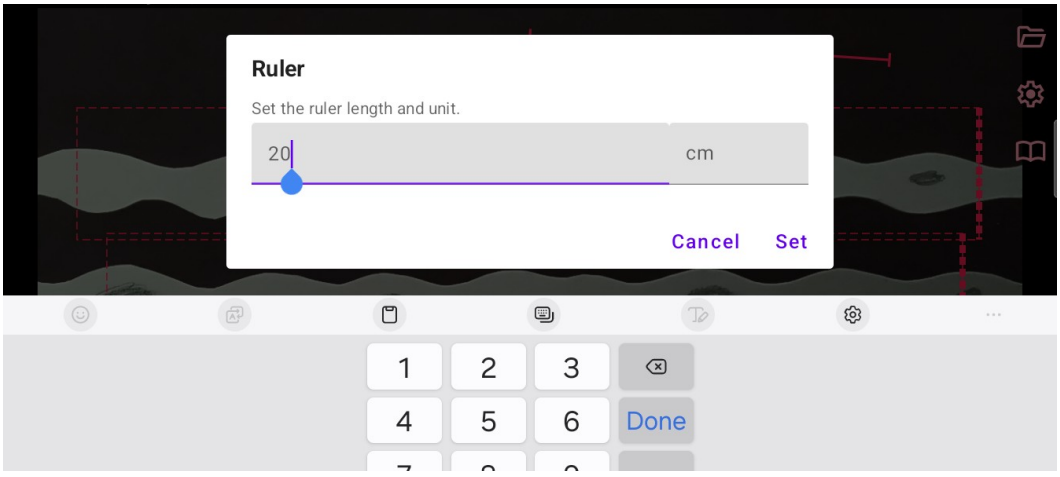
Once you are happy with the ROI name and map selection, press Set, or otherwise press Cancel. Now you need to “fix” the ROI. Double-tap within the ROI and its boundary will become dashed. The ROI will now not be responsive to any finger gestures, except double-tap if you want to edit it again.

Once you have created and fixed one ROI you can create further ROIs in the same manner. Each new ROI is initiated with the maximum threshold of any previous fixed ROIs, so that you do not have to adjust it.



Ruler

You can define the spatial scale of the FOV using the ruler. Move the ruler about by dragging its ends until each end is positioned at the ends of a known scale in the FOV (e.g. a section of a real ruler or pre-measured marks) at the same distance (focal plane) as the gut. Then double-tap one of the ends and a dialog appears from which you can set the length of the ruler and the units (mm, cm or inch). Doing this means that the map image files will include their real spatial resolution.



Start recording

When you are ready to record, press the green play icon.

As mentioned, each map is recorded into a pre-defined memory buffer and there are a fixed number of these so a fixed number of maps you can record at one time, no matter how many ROIs you create. If you exceed the number of buffers/allowed-maps the app will warn you of this with a dialog when you press to record and will block recording. In this case you *must* reduce the number of ROIs or maps per ROI. At present there are ten buffers and so ten maps can be recorded at once.

Before getting to the recording itself, it will be useful to go through the settings.

Settings

Tap the cogwheel icon to open the settings page. Use your device's back button to exit the page once you are happy with the settings.

Screen

Orientation. The app will work whatever the tablet's orientation. If you rotate the tablet the app, including the ROIs, will reorientate appropriately. In some (if not all) experimental set-ups, the tablet will be kept fixed in a flat position above the gut. The tablet will then not be able to detect the appropriate screen orientation. You can set the orientation here – the four possible orientations (the orientation will then be fixed) or "auto" to allow the tablet to detect an appropriate orientation again.

Controls on left. The controls (buttons for record-loading/settings/user-guide and slider for threshold/exposure) can be switched between the left- and right-hand side of the screen so a left or right handed user does not cover the screen with their hand when pressing them.

Keep on. If you want to stop the screen from ever going to sleep whilst the app is open.

Mapping resolution

Frame rate. The number of frames the camera captures in a second and thus the temporal resolution of the maps. This is an approximate frame rate (see *Frame timing*, below).

Spatial pixel skip. Instead of using each pixel along the length of the gut's ROIs, you can skip pixels to reduce spatial resolution. This will increase the allowable recording time – the total number of pixels sampled along the ROIs length is reported in the ROI dialog as "samples/frame" (see above).

Mapping algorithm

Threshold inversion. Contrast between the gut and background should be maximised to improve the thresholding performance of the mapping algorithm. Either the gut is light against a dark background (the more usual configuration) or dark against a light background. In the latter case, set threshold as inverted.

Minimum detection width. When recording is started, each gut is detected by thresholding along the seeding edge (see above). To be considered a "gut" the thresholded width along the edge must exceed a minimum number of pixels. A minimum width of 10 pixels is fine for most circumstances, but if you have quite a bit of "flotsam and jetsam" in the bath, you might want to increase the width so that the algorithm does not confuse these bits for guts.

Gap skip. Sometimes there might be the odd pixel within the bounds of the gut that is below threshold (or above, if the threshold in "inverted" - see above). For instance there might be small bubbles that pass across the gut, or a thin wire used to keep the gut in place. In these cases the algorithm needs to allowed to skip a "gap" of below-threshold pixels. A gap skip of 4 or 5 pixels is usually enough.

S**pine smooth**. The gut spine is smoothed by a number of pixels, thus differentiating the distances measured each side of the spine in the radii maps – see above.

Application

Save on close. If you close the app when it is recording, automatically save the maps. The map folder will be called "Auto_Saved".

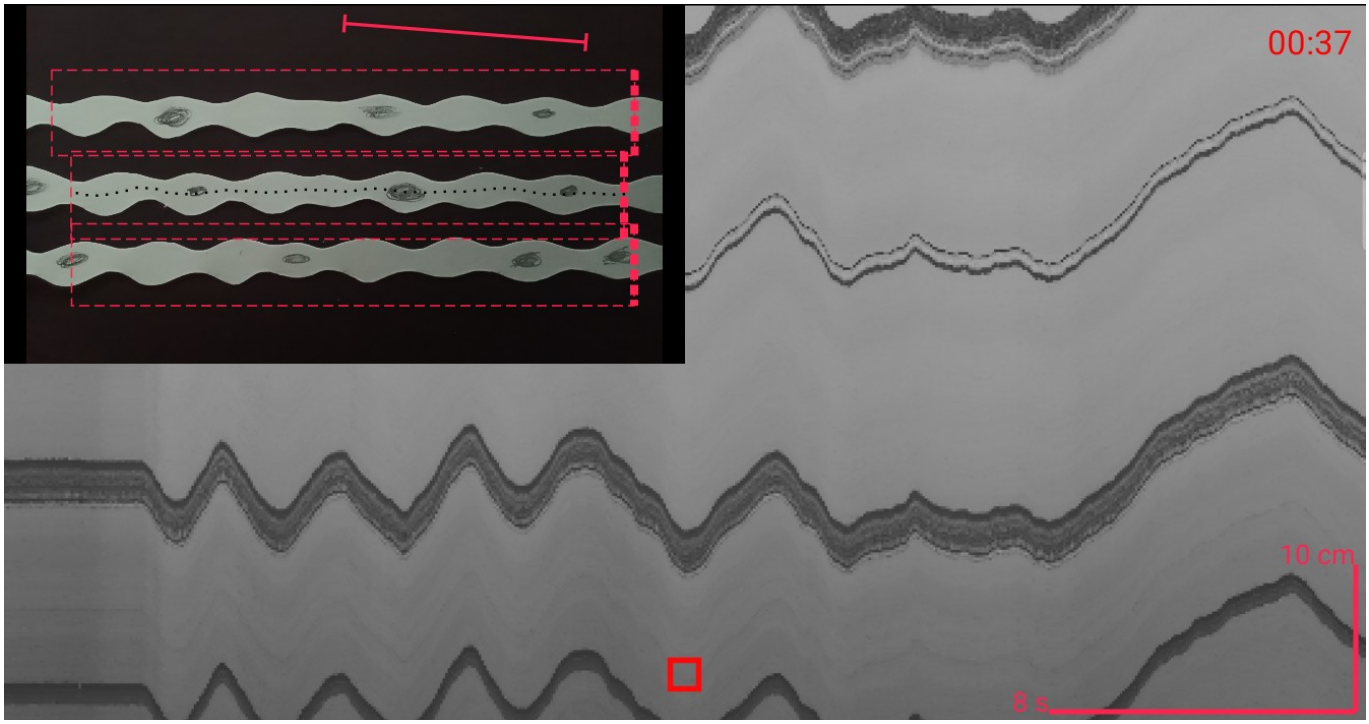
Record maps

With your ROIs created and settings set, you can now record maps. Press the play icon.

The FOV retreats into the upper left corner of the screen to reveal one of the maps being created. The FOV can be resized by dragging (with a single finger) at its lower right corner.

Time on the map runs from left to right and as it is added to at the right, it scrolls backwards. The seeding (thick) edge of the ROI corresponds to the bottom (landscape orientation) or right (portrait orientation) of the map. That is, the scale bar aligns with the leading edge of time and the seeding edge of space.

The map can be zoomed with finger-pinch gestures (along the axis to be zoomed) and scrolled by dragging with a single finger.



Change the shown map

The ROI of the map being shown is indicated by showing the gut's spine as it is calculated. Double-tap on any of the ROIs to show the maps in that ROI. Repeated double-tapping on the same ROI, loops through the maps of that ROI (if there is more than one).

Frame timing (map temporal resolution)

The amount of computation DMapLE has to do increases with:

1) The more maps/ROIs that are recorded.

2) The longer the length of the ROIs.

3) The smaller the spatial pixel skip (see *Settings*).

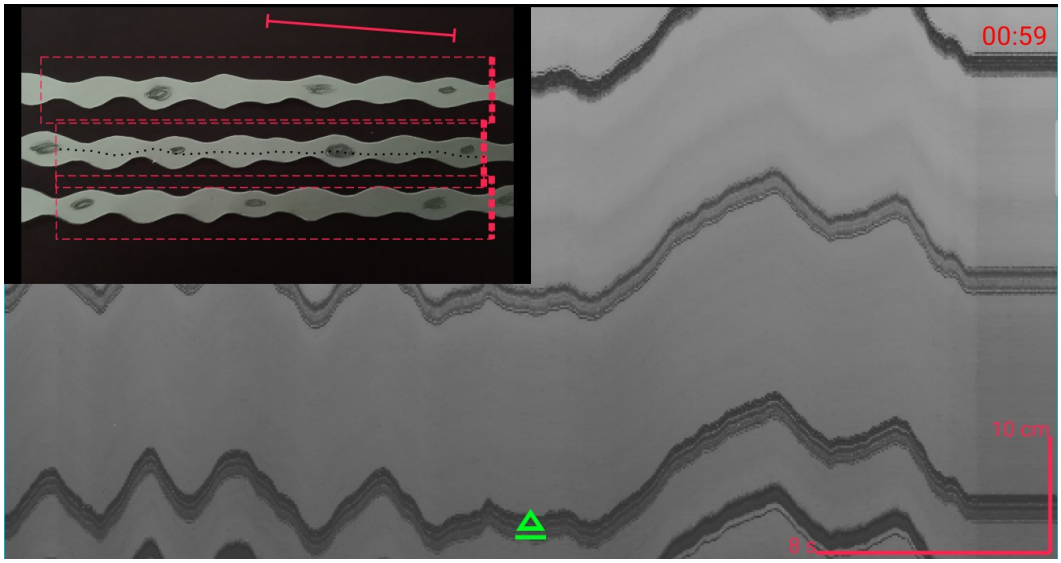
4) The larger the frame rate (see *Settings*).

If the amount of computation is too much, the time interval between frames (map samples) may be larger than that specified by the frame rate in the settings (above). If the mean difference, over the last 100 frames, is larger than 10% an asterisk will appear next to the top-right clock to warn you. In such cases you may want to reduce the number of maps/ROIs, reduce the frame rate or increase the spatial pixel skip.

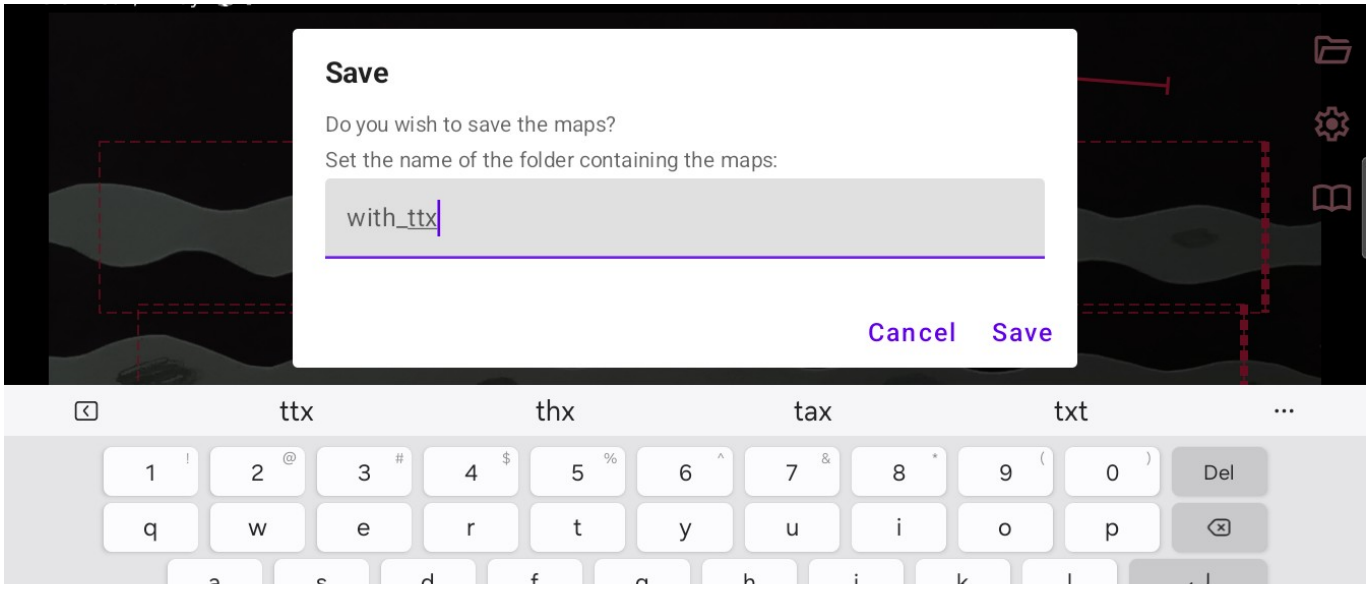
When you save a recording, the recording folder includes a file “timing.txt” that has the time at the start and end of the recording followed by the actual intervals between consecutive frames (in milliseconds). The first interval is always 0.

Stop and save

Press the stop icon to stop the recording. The stop icon is replaced by an “eject” icon. You can scroll, zoom and select maps to view, in the same manner as during the recording.



Press the eject icon and a save dialog appears. You can enter a name for the folder in which to save the maps - the default folder is “Maps” if the inputted name is blank. Map folders are saved into the public Documents folder of the tablet. If the map folder name already exists it is appended with _1, _2, etc. Press either Save or Cancel.



Once saved or cancelled you are returned to the full recording page, with the same ROIs.

Saved files

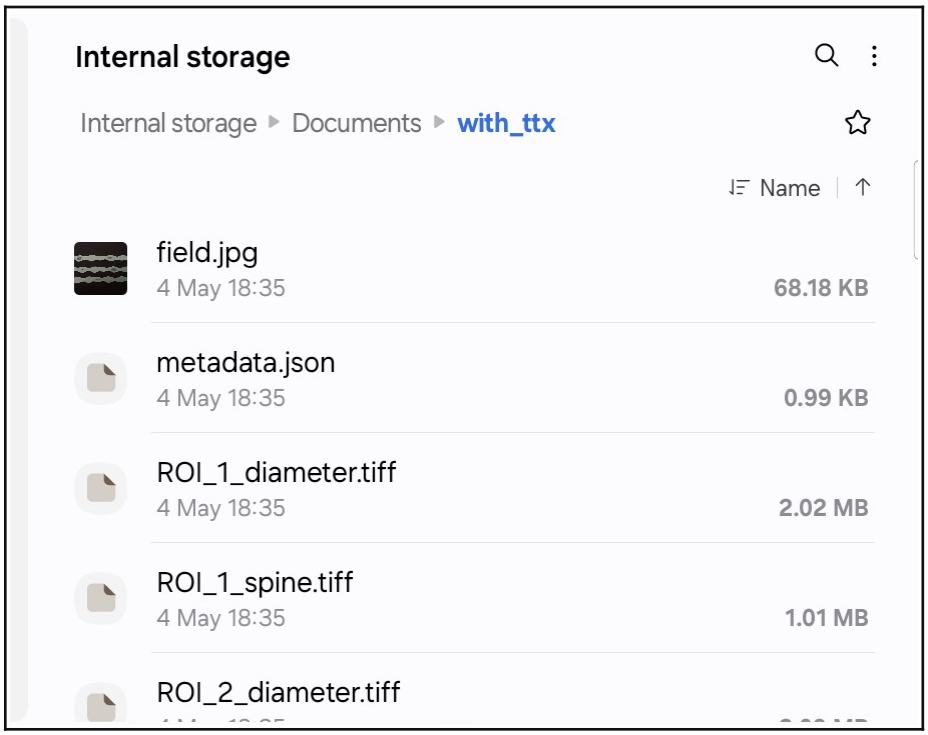
Each saved mapping folder contains:

field.jpg. A JPEG image of the last frame of the FOV.

metadata.json. A JSON containing information about the recording – the mapping parameters, the ROI dimensions, etc.

timing.txt. A plain text file containing the start and end times of the recording and the interval (milliseconds) between each temporal sample in the maps. The first interval is always 0.

<ROI name>_<map type>.tiff. A TIFF image of each map. The image name consists of the ROI name followed by the map type (diameter, spine or radius). Each file includes the map's spatial and temporal resolution in a format that is recognised by ImageJ and Fiji, so if you open them in these programs they will appear "calibrated" with their dimensions.



Scripts for analysis

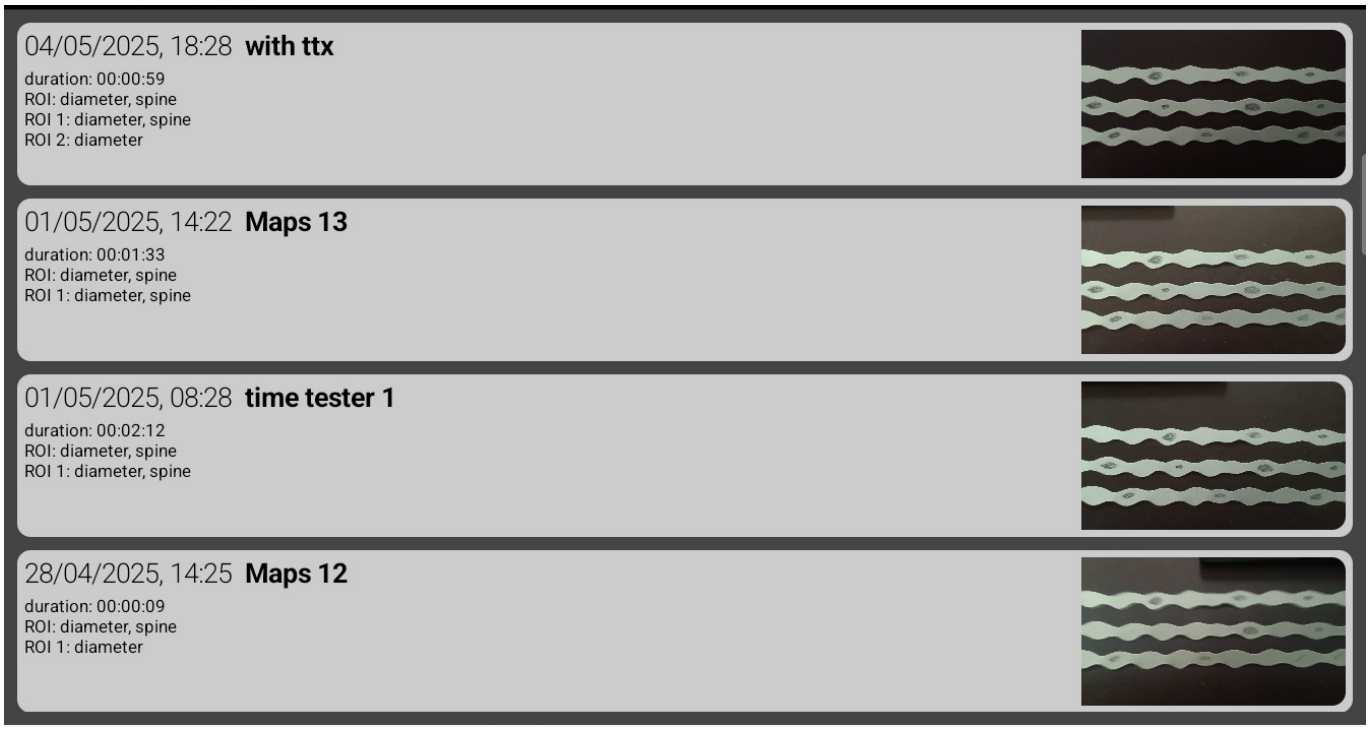
I have set up a public repository at https://github.com/sparsonslab/dmaple-scripts, that contains example Python and Jython scripts for analysis of recordings.

The Jython scripts are meant for running in ImageJ or Fiji. They include:

1) Adding the ROIs to the field JPG.

Load old recordings

In the app, press the folder icon and a vertically scrolling list of recordings opens, the “explorer page”.



Double-tap on any recording to “load” it. The recording opens as if it had just stopped recording and you can do the same things as for a live recording – zoom and scroll through the map and change the map shown by double-tapping on an ROI in the FOV. Press the eject icon and you are returned to the recording page with the *old* recording’s ROIs and ruler present (and editable) on the FOV.

Table | Mapping parameters after loading an old record.

Reproduced from old record	**Not Reproduced**
The ROIs – their size, seeding edges and thresholds.	Any parameters in the settings – frame rate, spatial pixel skip, etc.
The ruler – its position, length and units.	

If you don’t want to load a recording, use your device’s back button to exit the explorer page.

Further reading

Swaminathan, M. et al. (2016). Video imaging and spatiotemporal maps to analyze gastrointestinal motility in mice. *J. Visualized Experiments* 108, 53828.

Kendig, D.M. et al. (2016). Spatiotemporal mapping of motility in ex vivo preparations of the intestines. *J. Visualized Experiments* 107, 53263.

Parsons, S.P. (2019). Diameter mapping: an experimental guide.

https://www.scepticalphysiologist.com/code/DMapLE/IntestineBath.pdf