XIRIS Data-Set Labeling instructions

This document has all the information necessary to deliver quality labels for the images. The first section explains where the images come from. It also explains what features can be present in the images and what they represent. The second section explains all possible classification and segmentation options and when they should be selected or performed. The last section contains a visualization of the steps to follow for annotation of every image.

ATTENTION: Read all the sections and make sure to understand before attempting any labeling.

For any questions regarding the annotation process, or if something is unclear in this document, please send an email to the following address:

gjjhoutu@uwaterloo.ca

1 Background information

This section provides information about the data origin and the features visible in the image.

1.1 Data origin

The images provided are part of a very large data-set of approximately 557,000 images. These images are the frames from a combined total of 330 videos. These videos are acquired from 49 different industry sites. All videos taken are observing a MIG-MAG welding process. The process is chosen out of a multitude of welding processes since the majority of the industry partners use this process. Also, the MIG-MAG data-set is larger and more versatile than the data available for the other processes.

1.2 Annotation Software

Labelbox is an online suite developed for shared annotation. Multiple people are able to annotate / label images at the same time. An “administrator” creates projects, members and adds data-sets to the project. A “labeler” is has the ability to label / annotate images.

1.3 Class Balancing

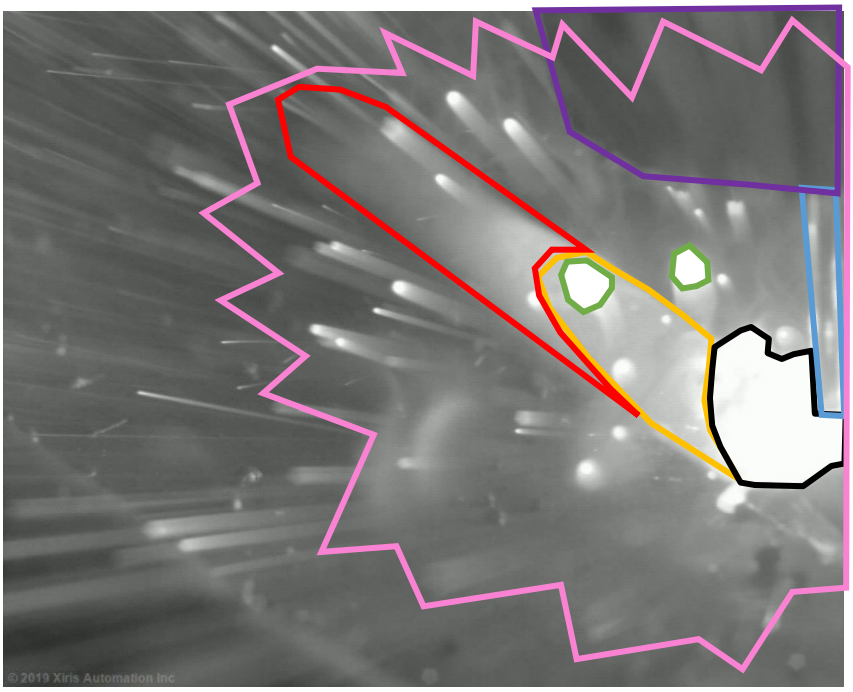
Along the way, the available data in the annotation project will grow. The reason is that once the first batch of images is annotated, another set of images will be selected from the very large data-set for annotation. The goal is to first balance the data-set. This means that in the end, we want an equal amount of annotated images per class. Since we do not know to which class an image belongs on beforehand, we have to find out while we are labeling. This is so called “Active learning”. A type of reinforcement learning with human feedback.

1.4 Typical image signature

A typical MIG-MAG welding image is shown below. Usually, several features are visible in the image, along with the melt-pool. The features are:

- **Nozzle.** The tip of the welding torch. This feature can be visible in the image. It also occurs that this feature “occludes” other features such as the melt-pool.
- **Wire.** The wire runs from the nozzle to the welding arc. It often occludes part of the melt-pool.
- **Arc.** The welding arc runs from the wire to the melt-pool. The arc is often very bright and can occlude other features such as the melt-pool boundary due to the saturation effect of the brightness of the arc on the camera sensor.
- **Weld / Melt-pool.** The non-solidified area of molten material. This area trails behind the welding arc due to the movement direction of the torch. Normally, a clear boundary is visible between the melt-pool and the solidified region.
- **Weld-bead / Seam.** This is the solidified material left after solidification of the melt-pool and trails behind it.
- **Spatter.** These are the ejected particles from the welding process. It could lead to severe occlusion of the other features.
- **Smoke plume.** During welding smoke can be produced for several reasons. This smoke can occlude the other features with the result that sharp gradients in the image are lost.

Nozzle
Wire
Arc
Weld-pool
Weld-bead
Splatter
Smoke plume



2 Image Annotation

This section contains all the classification and segmentation options. The order and process of annotation is not discussed in this section. This is discussed in section 3.

2.1 Image classification and segmentation

Each image **has** to be classified in **one** of the following 3 classes:

- No melt-pool
- Occluded melt-pool
- Segmentable melt-pool

2.1.1 No melt-pool

An image is classified as “no melt-pool” if there is **no way to define a region containing the melt-pool** in the image. There can be 2 reasons to classify an image as “no melt-pool”. Namely:

1. The melt-pool is **not present** in the field-of-view (FOV) of the camera:
   - The process did not start yet / or has already ended.
   - The process takes place outside of the FOV of the camera.
2. The melt-pool is **present** but completely occluded by other features in the image and there is **no way to define a region containing the melt-pool**

The terms are further explained in the following subsections.

2.1.1.1 The melt-pool is not present in the field-of-view (FOV)

If the process has not started yet, or if it already ended, then all the material in the image is solidified such that no melt-pool is present in the image. See Figures 2 and 3 for examples.

Figure 2: No melt-pool, process JUST ended. All material is solidified.

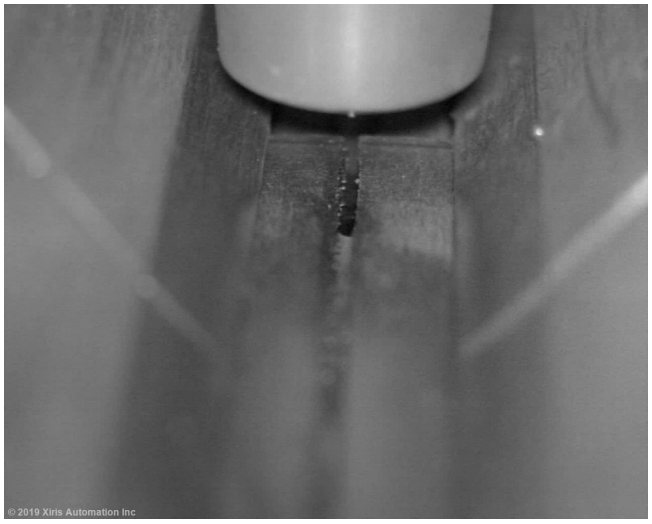


Figure 1: No-melt-pool, process did not start yet.

Another reason to classify an image as being “no melt-pool” is if the melt-pool is outside of the field-of-view of the camera. The way to tell if the melt-pool is present outside of the field-of-view is when there is significant bleeding of light from the melt-pool present at the edges of an image from the process. See Figures 4 and 5.

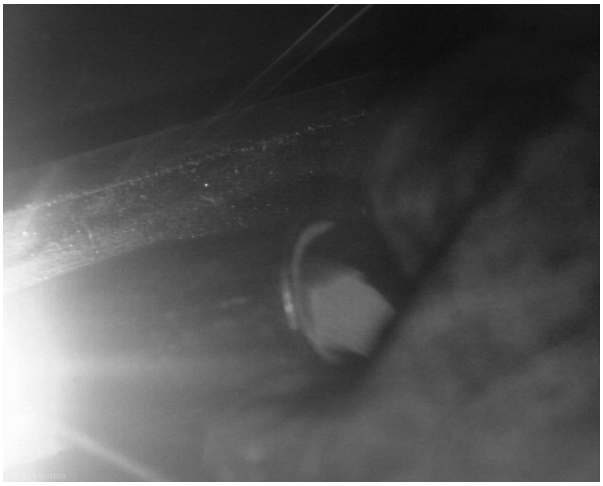


Figure 4: melt-pool is outside of the field-of-view. Arc light bleeds into the image.

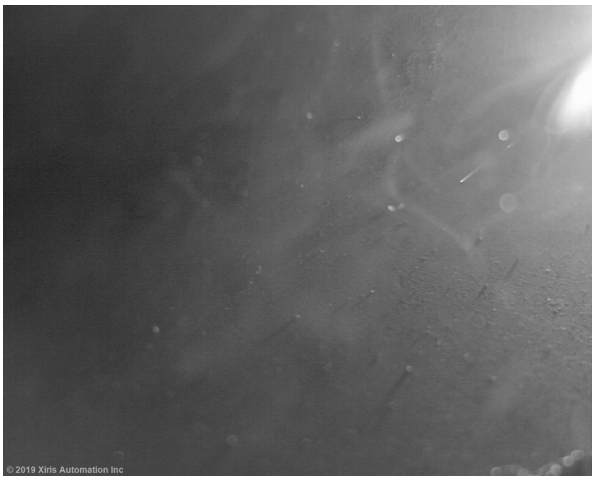


Figure 3: melt-pool is outside of the field-of-view. Light from the solidified seam is visible in the image

2.1.1.2 The melt-pool is present but completely occluded by other features

Another reason could be that the melt-pool is present in the field-of-view of the camera but simply not visible due to occlusions of other features or objects. Figures 5 and 6 show examples of occlusion by the welding torch or another object blocking the image. There is no way of defining a region that contains the melt-pool. See the next section to find out what it means to be able to define a region that contains the melt-pool.

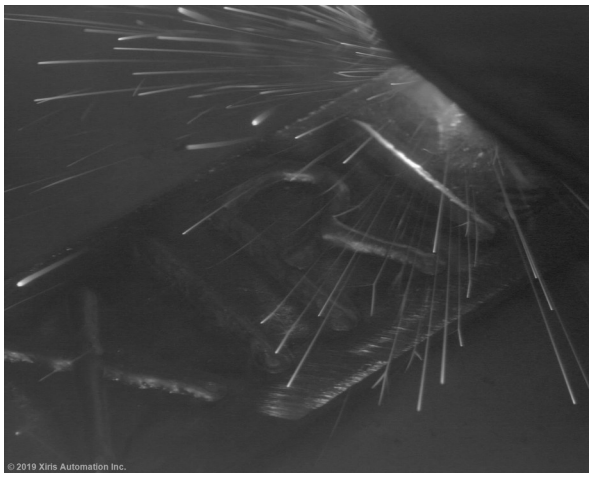


Figure 6: Melt-pool occluded by object. Spatter still visible

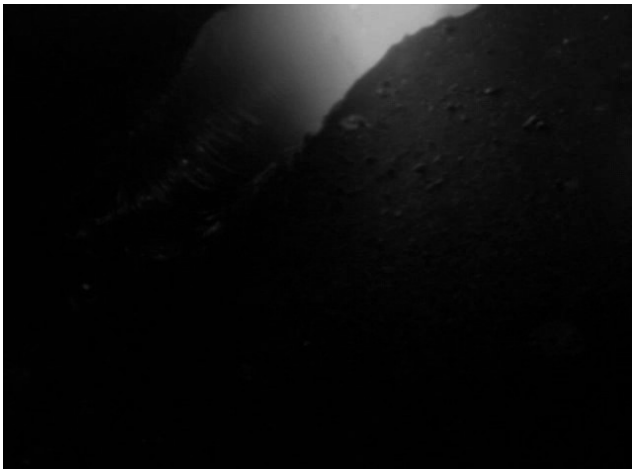


Figure 5: Melt-pool outside of field-of-view

2.1.2 Occluded Melt-pool

An image is classified as “occluded melt-pool” if there is a melt-pool present in the image but the melt-pool boundary is **occluded** in such a way that it is **impossible to segment at least partially the melt-pool**. You are only able to define a region or bounding-box around an area in the image that definitely contains the melt-pool, not a region of the actual (partial) melt-pool boundary.

Bounding-Box Segmentation

An image classified as either being “occluded melt-pool” or “segmentable melt-pool” needs to be segmented using a bounding-box. **The bounding box should be drawn around a region / area as small as possible that contains all the melt-pool area present in the image.**

Figure 8 shows a large amount of saturation. It is occluding the melt-pool completely. It is clear that the melt-pool is not present in the lower and right side of the image. It is however not clear where the melt-pool ends. That is why the bounding box extends towards the top and left side of the image.

Figure 7 shows an image with lots of spatter, arc saturation, smoke and occlusion by the welding torch. It is not clear where the melt-pool ends therefore the bounding box extends towards the left side of the image.

Figure 8: Occluded Melt-pool. The image is saturated. The melt-pool is definitely present inside the saturated area. Therefore the smallest bounding box containing the melt-pool is around the edge of the saturated area.

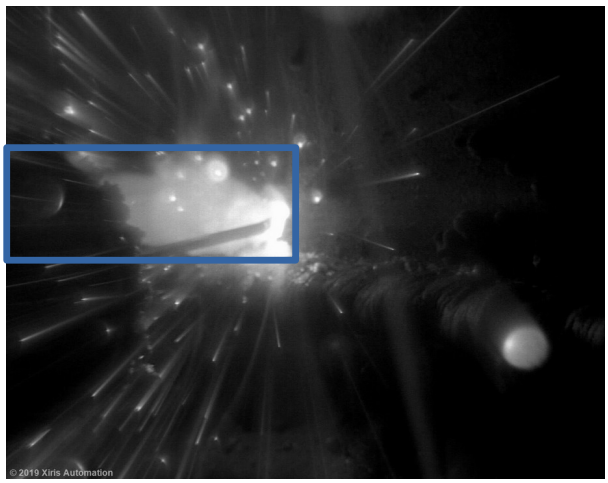


Figure 7: Occluded melt-pool. The boundary of the melt-pool cannot be determined due to the effect of spatter, the welding arc and the lack of a clear separation boundary of the melt-pool. A containing bounding-box can be determined.

Figure 9 shows partial occlusion by the welding torch. The smoke plume occludes the rest of the melt-pool boundary. It is impossible to define a melt-pool boundary. It is however possible to define a region that definitely captures the present melt-pool in the image. Since it is unclear how far the melt-pool extends to the top the bounding box extends towards the top of the image.

Figure 10 shows occlusion by other material. It is impossible to define an actual melt-pool boundary. A bounding box region can however be defined that definitely contains all the melt-pool present in the image.

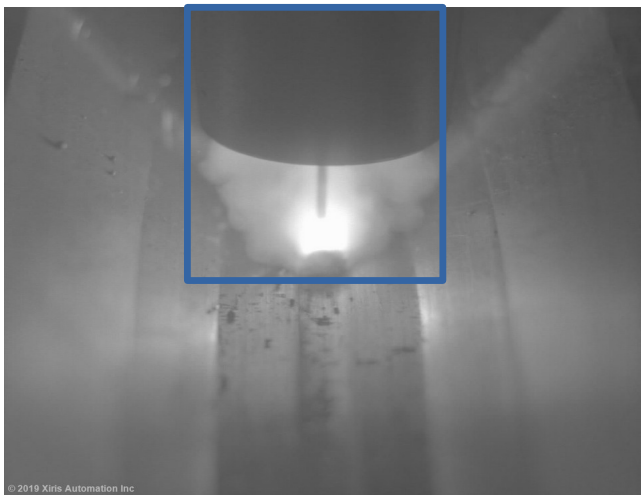


Figure 9: Occluded melt-pool. The smoke completely occludes the melt-pool boundary. The melt-pool boundary is however definitely present inside the smoke. The smallest bounding-box is the region surrounding the smoke.

Figure 10: Melt-pool occluded by other material and smoke.

2.1.3 Segmentable Melt-pool

An image is classified as “segmentable melt-pool” if there is a melt-pool visible in the image and a melt-pool boundary is visible separating the melt-pool from the solidified material. Determining if an image can be segmented can be hard. Some cases are easy to segment while others are more difficult.

Semantic segmentation

If classified as “segmentable melt-pool” then a bounding-box needs to be drawn around the region containing the complete melt-pool. This is equivalent to bounding box segmentation as if classified as “occluded melt-pool”. Besides the bounding box segmentation, Semantic segmentation needs to be performed to separate the **visible** melt-pool region from the rest of the image. Two cases often arise:

- Complete segmentation
- Partial segmentation

Complete segmentation

Ideally, all images belong to this class and are as easy to segment. Figures 9-12 are examples of images which are easy to segment and are complete. The semantic segmentation is **complete** meaning that the semantic segmented region touches all the edges of the bounding box. Figures 11-14 show examples of images:

- Classified as “segmentable melt-pool”
- A bounding-box region containing all of the melt-pool present in the image
- A segmentation boundary containing a region definitely belonging to the melt-pool since there is a visual boundary.

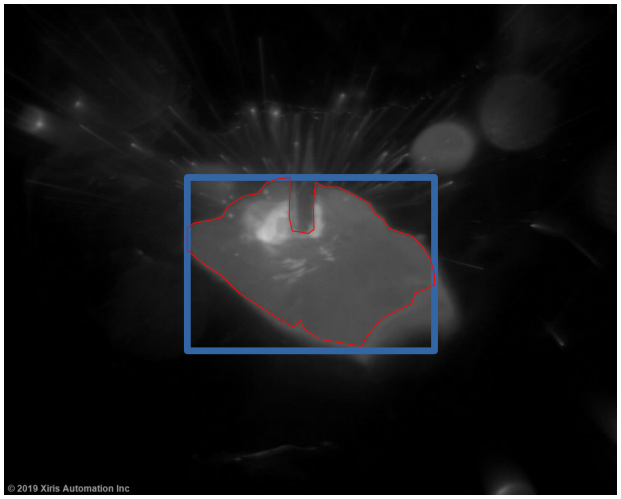


Figure 12: Small amount of spatter. Great separation between melt-pool and solidified material

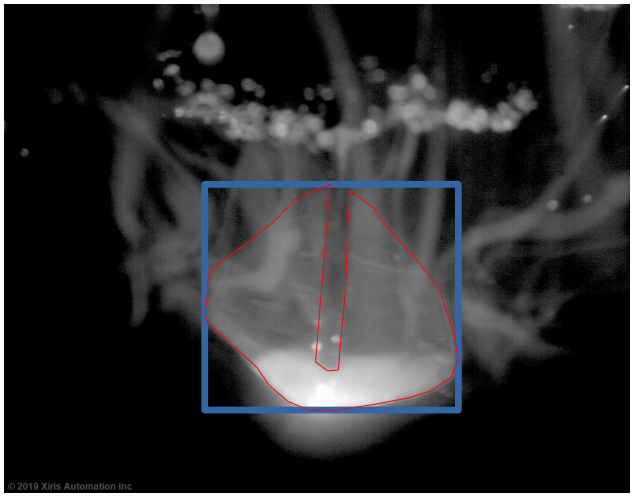


Figure 11: Smoke occludes the melt-pool. The boundary is however still visible.

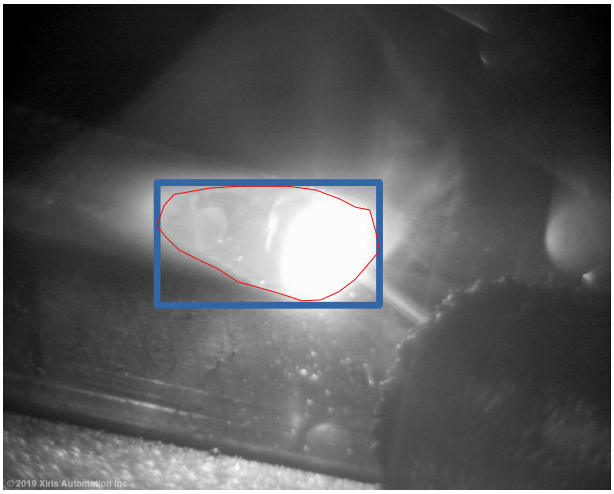


Figure 14: Saturated core region. The melt-pool boundary is still well visible

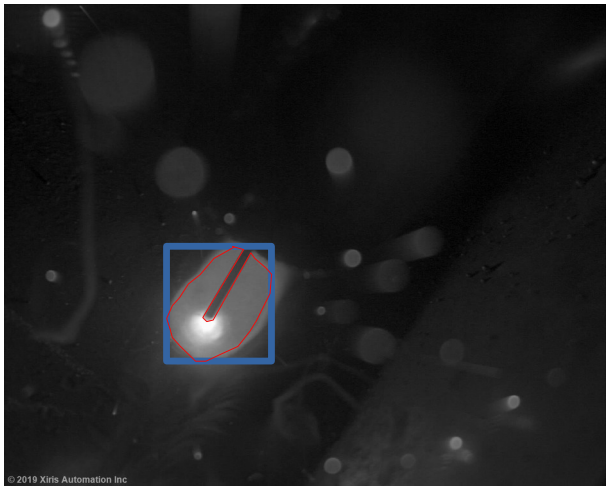


Figure 13: Partially occluded by the wire. Still easily segmented.

Partial segmentation

Often, The visible melt-pool boundary is only part of the actual melt-pool region present in the image.

- The bounding-box has to surround the region which contains the present melt-pool in the image.
- The segmentation boundary has to surround the region which contains the visual melt-pool in the image.

Figures 9-12 are examples of images with partial segmentations.

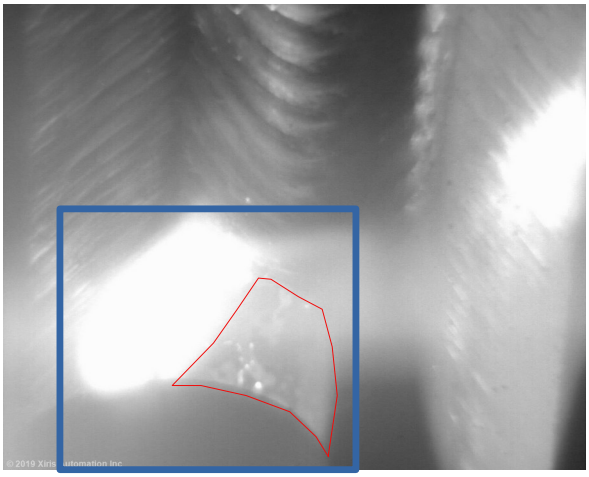


Figure 15: The bounding box surrounds the visual melt-pool and the saturated area. The polygon surrounds the visual melt-pool boundary.

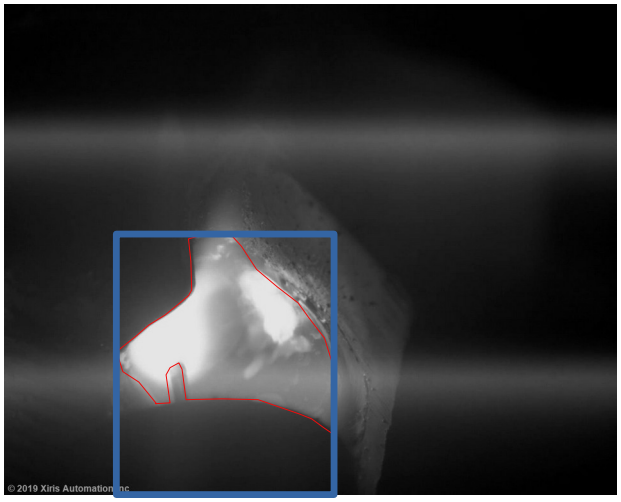


Figure 16: Although partially occluded by the welding torch the melt-pool region boundary can still be determined

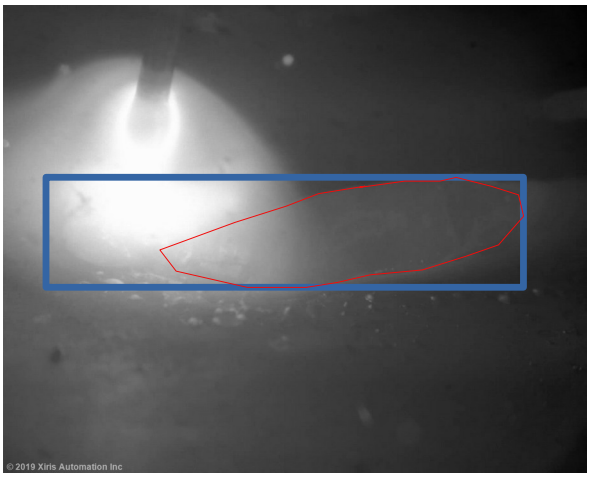


Figure 17: The arc occludes part of the melt-pool region.

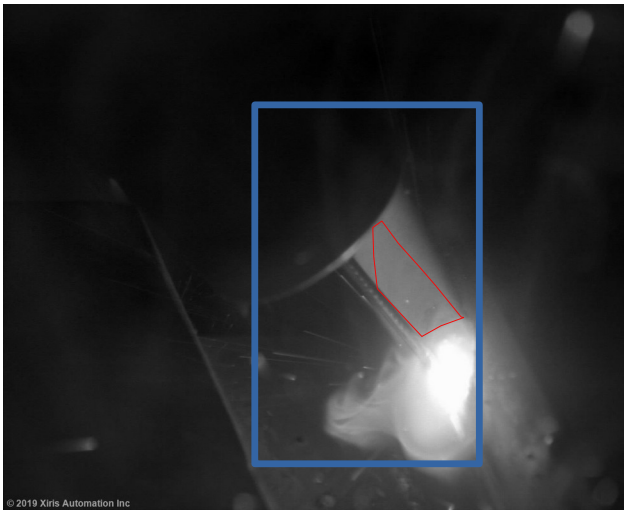
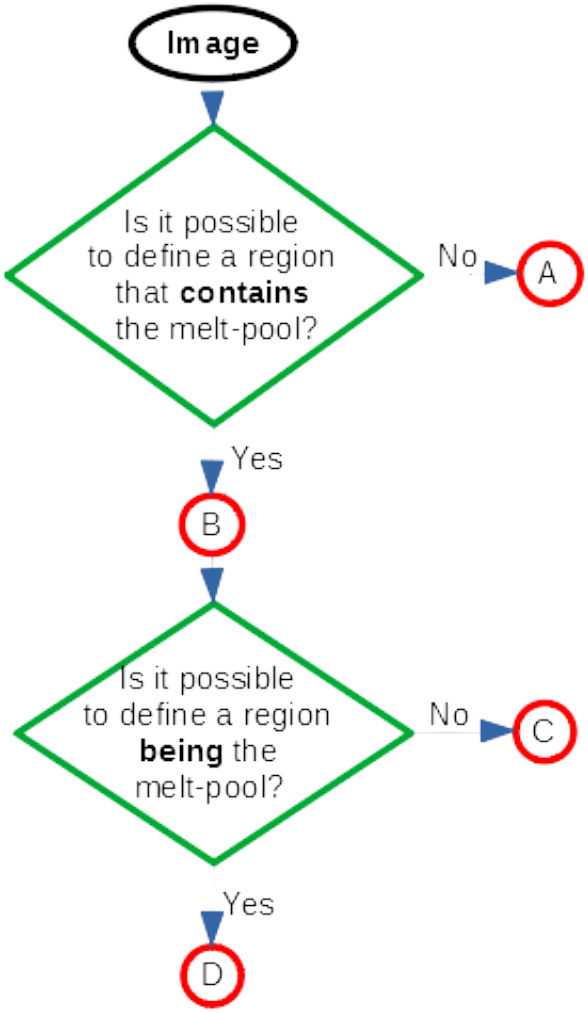


Figure 18: The wire, torch, arc and smoke plume are blocking the melt-pool present in the image. The visual melt-pool boundary is a small part of the bounding box.

3 Image annotation steps



A: No Melt-Pool in image

Choose when:
1) No process in Field-of-View
   - Process did not start yet
   - Process already ended
   - Melt-pool outside of image
2) Melt-pool completely occluded and no Idea where it is located in the image
   - Welding torch blocks melt-pool
   - Other solid objects blocking

Actions:
Classify as "No Melt-Pool"

How to:
Select the "No Melt-pool" option in
The drop-down menu named "Choose One"

B: Melt-pool in image

Choose when:
1) The melt-pool boundary is visible
   - Can be partially visible
   - Can be completely visible
2) Melt-pool is (partially) occluded but you can define a region in the image definitely containing the melt-pool.

Actions:
Draw a bounding box around a region that definitely contains the Melt-Pool region. If a feature is occluding the region then draw the box around the feature. If the feature covers The whole image then draw a bounding box Around the edges of the image.

How to:
Select "Melt-pool region" and draw the bounding box

C: Occluded Melt-Pool

Choose when:
1) No melt-pool boundary in the bounding box can be selected which definitely belongs to the melt-pool.

Actions:
Classify as "Occluded Melt-Pool"

How to:
Select the "Occluded melt-pool" option in the Drop-down menu named "Choose one"

D: Segmentable Melt-Pool

Choose when:
1) A (partial) melt-pool boundary can be selected in the bounding box region.

Actions:
- Draw a very precise polygon around the Melt-pool boundary
- Classify as "Segmentable Melt-Pool"

How to:
-Select "Melt-pool boundary" and draw very precise polygon around the melt-pool boundary.
- Select the "Segmentable melt-pool" option in the Drop-down menu named "Choose one"