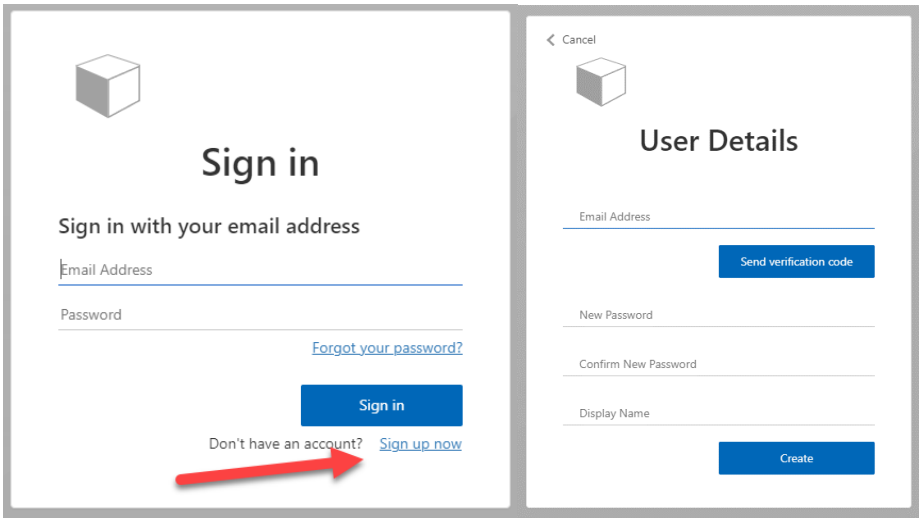
AI Headstamp Sorter Application Guide

For software version 1.1.47 (1)

Table of Contents

Download and Install

To download the software, visit https://www.reloadingrecipes.com/HeadstampSorter and click the link to go to the downloads page. You will be required to create an account if you don't have one already. To create an account, click the **Sign up now** button. Minimal information is required to create an account though your email address should be valid to activate the account.



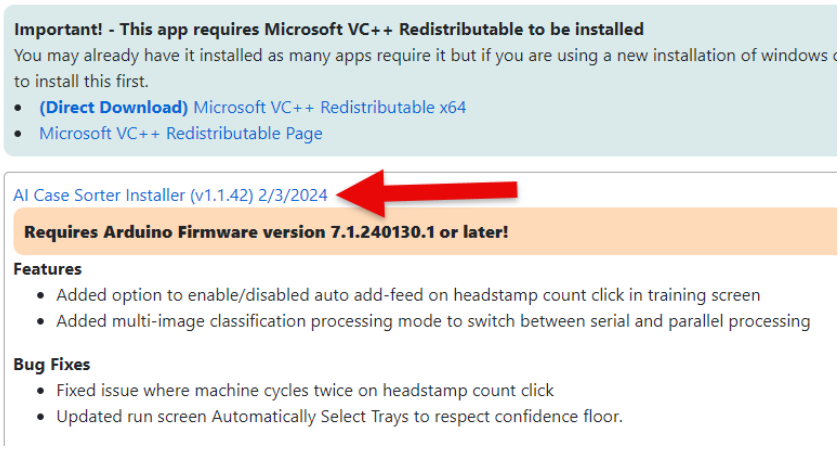
A note on Privacy and Data Protection and Internet Connectivity

Though there is not an official privacy policy, the only data being collected is the account information you input when creating the account which is Email, Password & Display Name. Passwords are stored in one-way hash and cannot be decrypted. The email is validated on initial account creation.

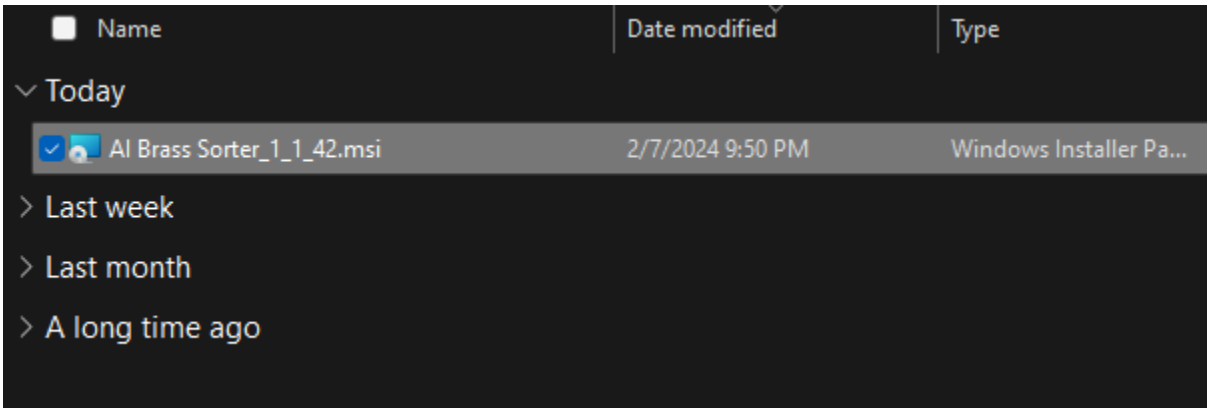
The application requires sign-in to run initially and automatically generates an offline license based on the machine key. The offline license is good for a year after which time, you would be required to sign-in again to generate a new license.

Pre-Installation

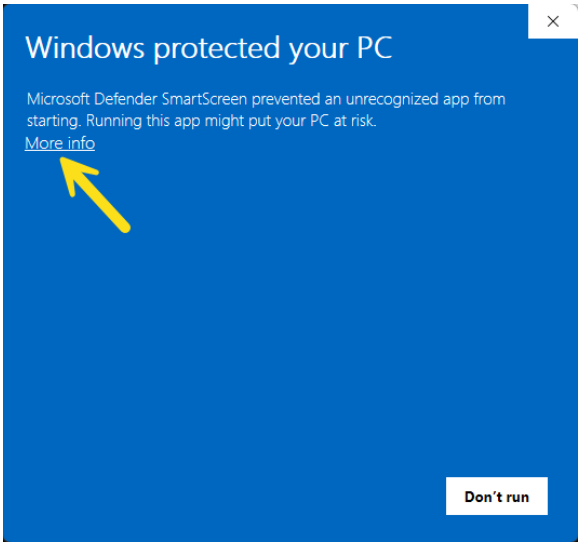
Once you have created your account and signed in, you can download the software by clicking the link to the latest version. It is a good idea to also ensure that you have the Microsoft VC++ Redistributable installed as well. Most systems will have this installed already but if you skip this step and run into issues installing the software, you might have to come back and install the redistributable.

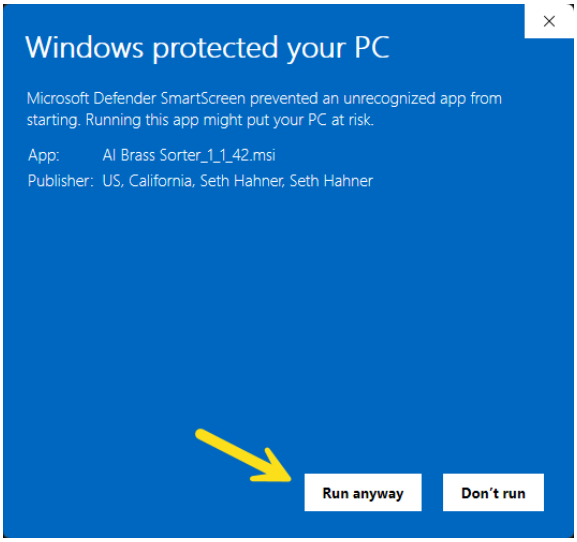


Once your download is complete, you can launch the installer to begin the installation. The installer should look something like the following screenshot.

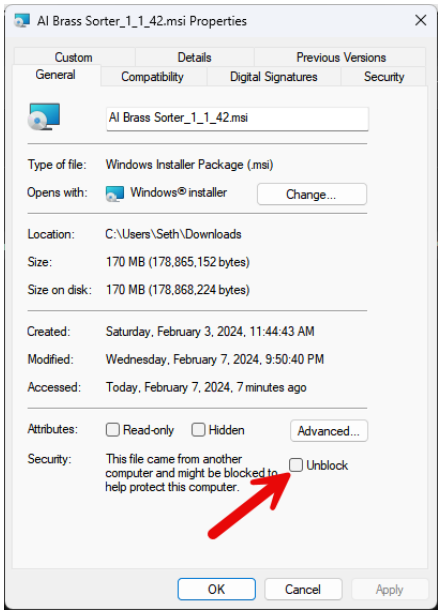


After launching the installer, you may receive a notification from Windows Defender SmartScreen as seen in the following screenshot. If so, click on the “More Info” link and then you will be given the option to install anyway.



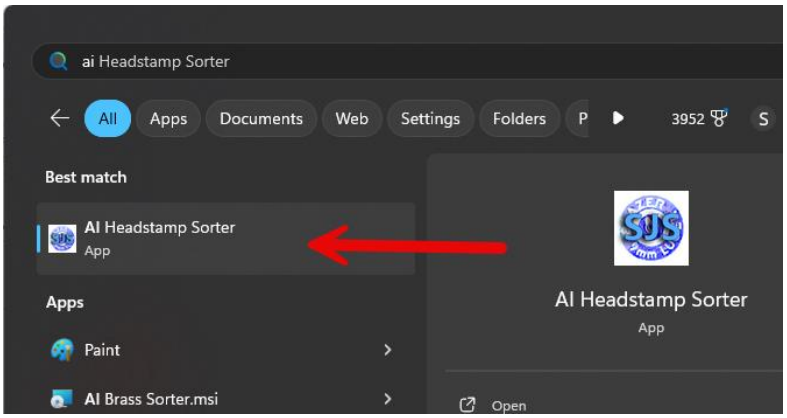


Alternatively, you can close this window and then right click on the file and go to properties and check the “unblock” check box. After unblocking, you should be able to run the file without the above messages.

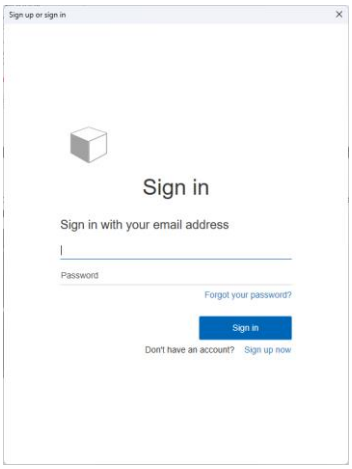


Once you have completed the installation, you can launch the application by going to your start menu and searching for “AI Headstamp Sorter”.

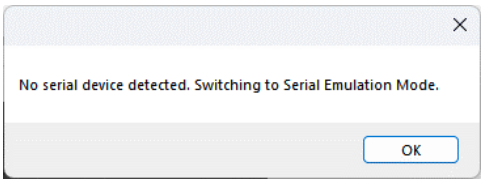
Starting the Software



The first time the software is launched, you need to have an internet connection. You will see a prompt that requires that you sign-in again with the same account you used when you downloaded the software. The application may reach out to the internet initially to download additional assets required for the machine learning elements (usually seen during the first training). It is recommended before air-gapping (removing network connection), that you sign-in, create a basic model with a couple classifications (in emulator mode) and then train the model. You probably want to do this twice (once with deep learning enabled and once without). After that point, the network cable/wifi can be “unplugged” and the system will operate in offline mode for a year unless the hardware internally is changed significantly.



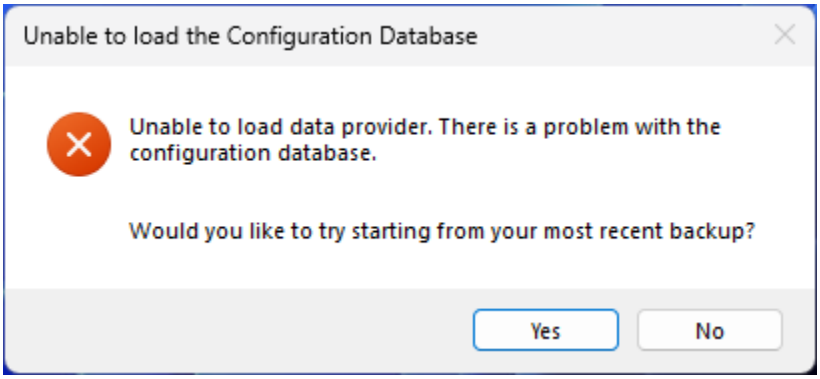
Once you have completed the sign in process, the software will launch. If the sorter hardware is not yet connected to the computer (via USB cable), the software will launch in “Emulation Mode” and you will see a prompt indicating so.



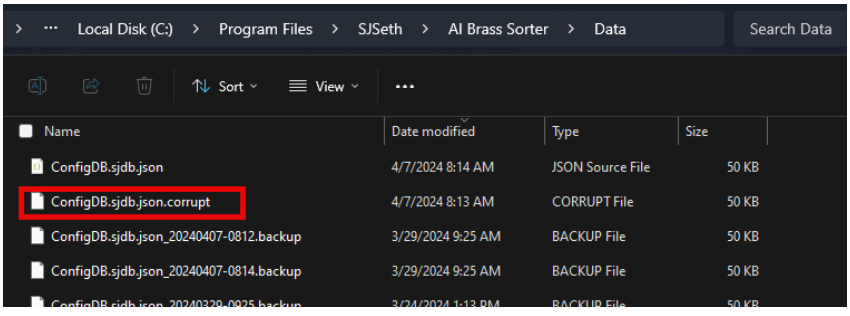
The software also requires that you have a web camera attached to the system even to run in emulation mode. If you do not have a camera, you will see an error message indicating it is required and the software will close.

Corrupted Data File Exception

In the unlikely event that your configuration data file has become corrupted, as of version 1.1.47, the software will prompt you of the event and ask if you would like to start from the latest backup.



If you select no, the software will exit. If you select yes, the data file will be renamed with the extension “.corrupt” and be replaced by the latest backup.

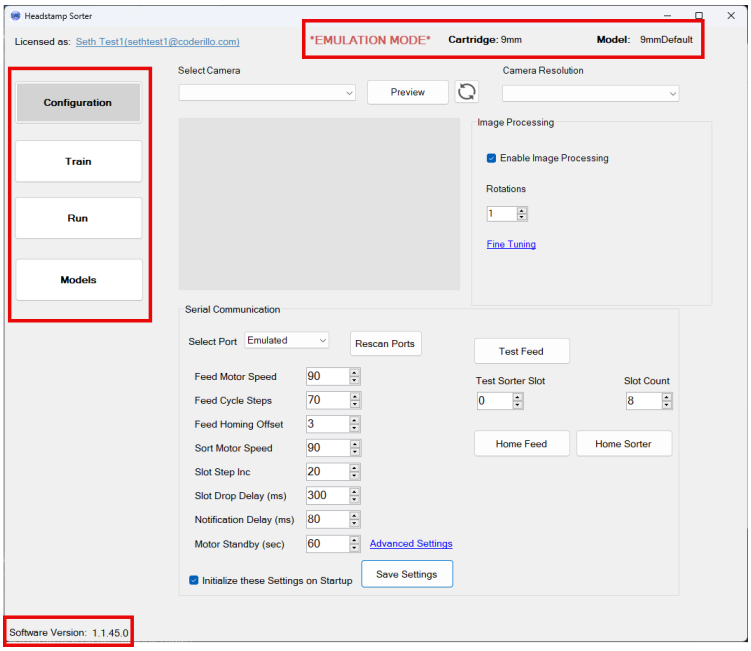


Backups are taken automatically whenever a configuration change is saved. The last 10 backups are retained.

Getting Started

On successful launch, the software will open into the Configuration panel.

The areas boxed in red from the screenshot below are “global” and will be seen on nearly all pages of the software. On the left, there are the navigation buttons, at the bottom is the current application version and in the top right corner is the currently selected Cartridge and Model. There is a default empty model created as seen in the screenshot.

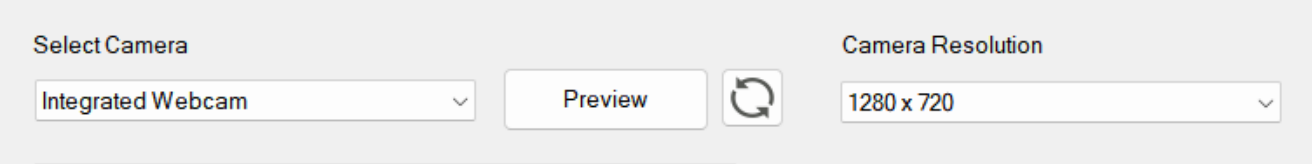


There are 4 main areas in the software and corresponding navigation buttons.

- **Configuration** – This screen and child screens (advanced settings and fine tuning) control the configuration for the application and the runtime Arduino settings.
- **Train** – The training screen is where you capture training images when creating a new machine learning model. A model must be created, have images added to it and be trained before any sorting can be done
- **Run** – The run screen is where you do the actual sorting. Once you have created and trained a model, you will select how you want things to be sorted and start the sorting process.
- **Models** – The models screen is where you can create and manage your cartridges and corresponding machine learning models. By default, the 9mm cartridge has been created along with a default empty model. In emulation mode, the emulated pictures are captured from 9mm brass and you can experiment with adding and classifying images into the default model.

Configuration Screen

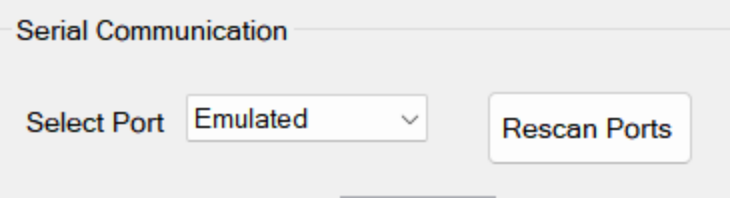
Camera Selection and Resolution



A list of connected web cameras will be displayed in the top corner of this screen. Clicking the Preview button will display a feed from that camera.

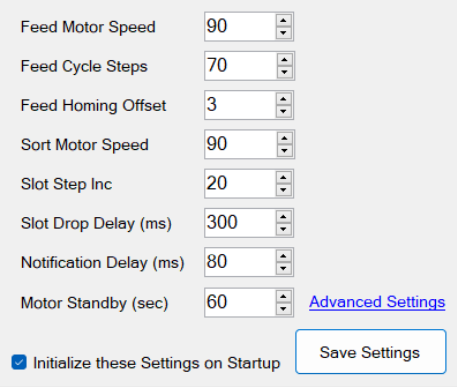
There are two camera versions for this sorter build (v1 and v2). The recommended resolution for the v1 camera is 640x480 and the v2 camera is 1280x720. Select the appropriate resolution for the camera you have selected.

Serial Communication



This section allows you to select from a list of detected devices. If your sorter is connected, you should see a COM port present in this list. If you do not, try disconnecting the USB cable and reconnecting it and then click the "Rescan Ports" button. If it detects the device, it will automatically be selected and visible in the list. If not, the application will remain in Emulation mode.

Hardware Configuration Settings



These settings can be used to override the default settings on your Arduino firmware. They will only be applied temporarily and will be reset when the Arduino resets or is powered off. To ensure the settings are always used, you need to check the checkbox titled "Initialize these Settings on Startup".

Here is a summary of each of the settings:

- **Feed Motor Speed** – range of 1 to 100 which controls how fast the feed motor turns. A speed of around 90 is usually preferred here.

- **Feed Cycle Steps –** This setting is mostly an artifact from when the sorter did not have a homing mechanism. If a homing switch is connected, this setting should be set to 70. If a homing switch is not connected, this setting should be set to 80 as that is the number of steps between each position in the feed wheel. The setting represents the number of "blind" steps the motor should run before looking for the homing switch signal.

- **Feed Homing Offset –** This is the number of additional steps the motor should turn after the homing switch has been triggered. If can help with centering your brass over the camera but you must be careful not to use too large a value here as it can cause the system to overrun the homing sensor. After setting this system, it is recommended to test feed the system at least 6 times to make sure that the homing sensor is activated

at rest for each position on the wheel.

- **Sort Motor Speed –** The speed of the sorter motor. Again, a value of around 90 is recommended for smooth operation. If your sorter is losing position, you can try reducing this value as an alternative to increasing voltage on the motor controllers.

- **Slot Step Inc –** Default value is 20. This represents the number of steps between each slot/tray/bucket on your sorter machine. The stepper motors for this project have 200 steps per revolution or 1.8 degrees per step. If you wanted to create more slots, you simply need to have a longer sorter tube outfeed. This will allow you to reduce the number of steps between slots. You would also need to increase the number of slots in the configuration screen.

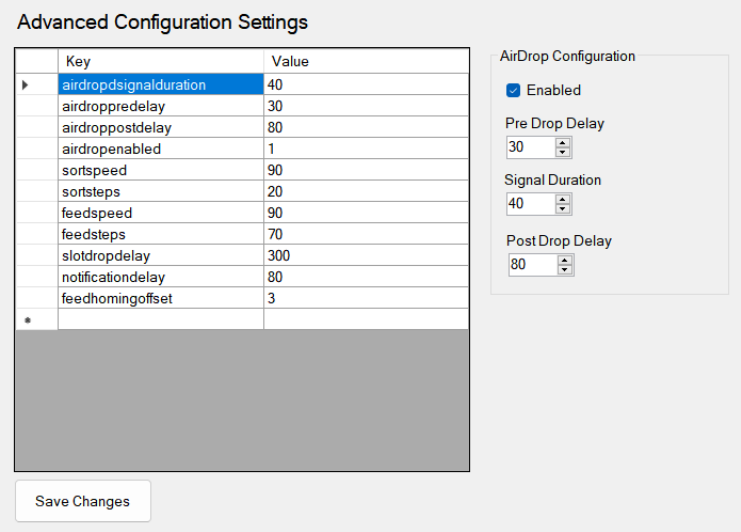
- **Slot Drop Delay –** This represents the amount of delay (in milliseconds) the sorter will wait before moving to the next slot. This allows time for the brass to fall and clear the sorter tube before it moves to the next slot. You can decrease this time and improve performance if running on a slower computer as there will already be natural delay built in.

- **Notification Delay –** This is the delay (in milliseconds) that the Arduino will wait after a feed cycle has completed before sending the done command. Generally, the brass case is still moving slightly when the feed cycle completes, and this results in a blurry image. Adding a bit of delay here allows the resonance and movement to stop before the software captures an image. If you are getting motion blur in your images, you should try increasing this setting in increments of 20 to find the optimal/minimal delay.

- **Motor Standby (sec) –** This represents the time in seconds to wait after motor inactivity to turn the motors off. Turning the motors off when not in use will help reduce heat and power consumption. It is generally recommended that this value be a number above 30 seconds, however lower values will work too. When the motor goes into standby, you may notice that the feed wheel reverses backwards a few millimeters depending on the strength of the tension cam spring.

Changes to the settings above will not be applied until the **Save Settings** button is pressed.

Advanced Settings



Advanced Configuration Settings

The table listed in this section represents the key / value pairs which will be sent to the Arduino microprocessor on initialization (if initialization enabled on previous screen). The values can be directly modified here. If you are using customized Arduino firmware, you can configure your own custom values here. Values pairs will be sent to the Arduino in a string like "key:value", for example: "feedsteps:70". The Arduino code should respond with an "ok" message.

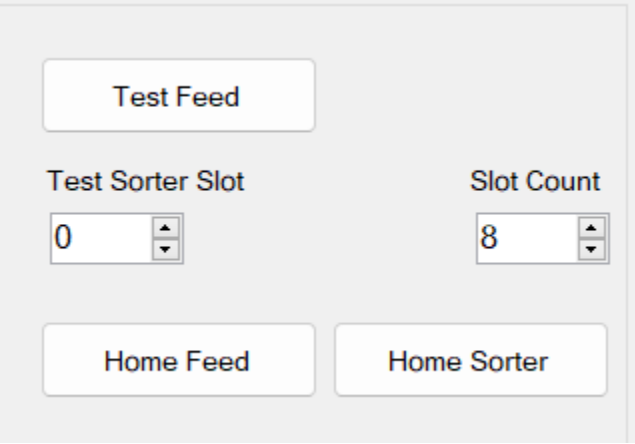
AirDrop

The airdrop configuration section was created as a convenience to allow easy configuration of the airdrop mod. As you change these settings, the airdrop config values will be added to the configuration grid. You must Save the Changes for them to be pushed to the Arduino and take effect.

To read more about the airdrop mod, you can visit the Mods folder in the GitHub repo at:
https://github.com/sjseth/AI-Case-Sorter-CS7.1/tree/main/Mods/AirDrop

Testing

The configuration screen also has a testing section as seen in the screenshot below:



Most of the controls here are somewhat obvious but here is a summary of each:

- **Test Feed** – Will cause the feed wheel to move forward one position. Ignores the state of the feed proximity sensor and does a force feed (xf:0) command.
- **Test Sorter Slot** – Moves the sorter arm to the selected slot position by sending the force move command (sortto:1)
- **Home Feed –** This sends a homing command and causes the feed wheel to move to the next homing position if not currently homed.
- **Home Sorter –** This causes the sorter arm to move to its home position.
- **Slot Count –** This is not actually a "test" feature but a part of the software configuration and enabled the software to recognize more slots than the default of 8. **Note that if you increase the slot count, you will need to reduce the **Slot Step Inc** setting as there are only so many degrees in a circle. For more information and an example on how to use this feature, check out the Long Arm Hex Sort mod at: https://github.com/sjseth/AI-Case-Sorter-CS7.1/tree/main/Mods/Long%20Arm%20Hex%20Sort*

Image Processing

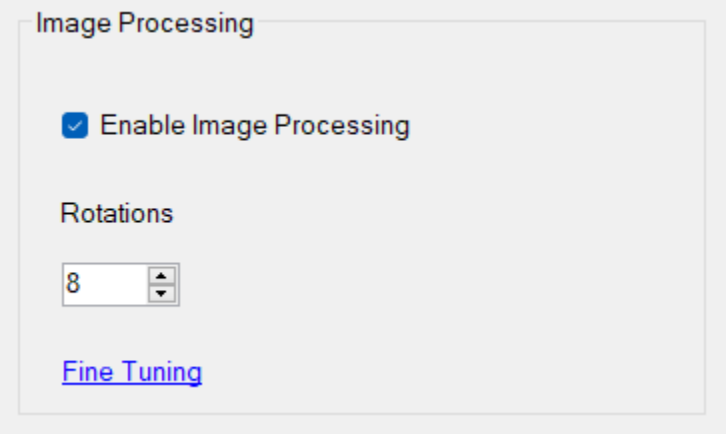
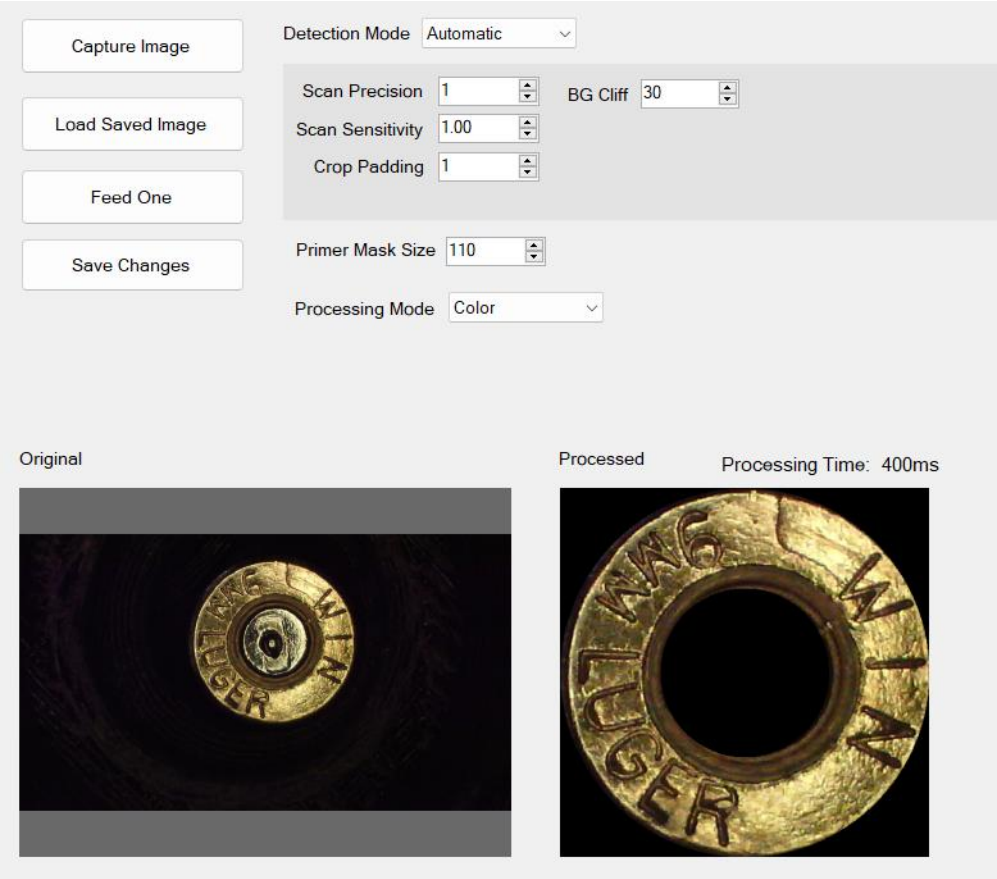


Image processing is the part of the software which is responsible (if enabled) for detecting, centering, and cropping the pictures of brass as well as creating rotations of those images. If this feature is not enabled, the raw image as captured by the camera will be used for the training.

Image Processing Fine Tuning



The fine-tuning screen is used to adjust the image processing settings used to detect, center, crop, mask the images as well as control color processing modes.

Some of these settings are stored in the currently active model and one should note that whatever settings you use here to capture and process images for your model, the same settings should be used when using the model in Run mode as a mismatch here will create poor recognition performance issues.

To begin tuning, you first need to load an image. You can use one of the 3 methods (buttons) on the left of the screen to do this. Here is how each of these methods works:

- **Capture Image** – This will capture an image from the Camera. If in emulation mode, it will randomly select an image from the emulation images folder.
- **Load Saved Image** – Use this feature to load a previously saved image. It defaults to the image processing tuning folder at: C:\Program Files\SJSeth\AI Brass Sorter\training\images\tuning. This is where images are saved when the ***Save for IP Tuning*** button is pressed in the **Training** screen.
- **Feed –** Similar to the functionality in the training screen, this initiates a feed cycle and then captures an image.

Detection Mode

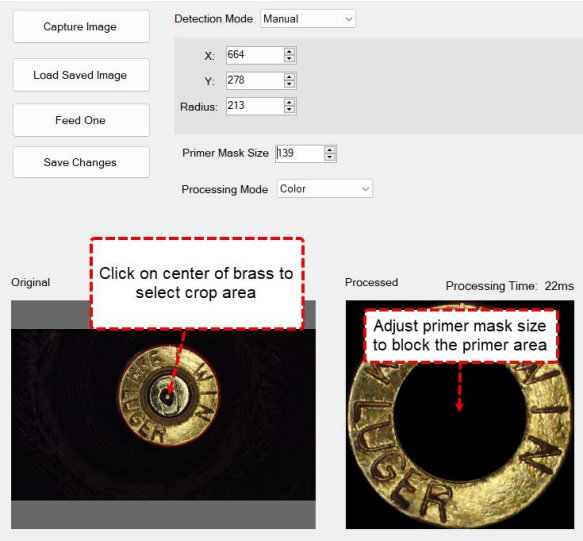
There are currently 3 detection modes which are used to locate, crop, and center the brass.

- **Manual** – User decides the crop area by selecting it. This is the fastest mode but often can create inconsistencies in the images as the brass can move a little from feed to feed.
- **Auto** – Machine detects the crop area automatically. This mode scans the entire image and can be a bit slow on some computers.
- **Hybrid** – (RECOMMENDED) Combination of Manual and hybrid where user selects a larger crop area and then uses automatic detection within the user's selection. This provides a balance of consistency and performance.

The following is a description of the settings for each of the above modes.

Manual Detection Mode

You can click on the original image to set the initial crop area.



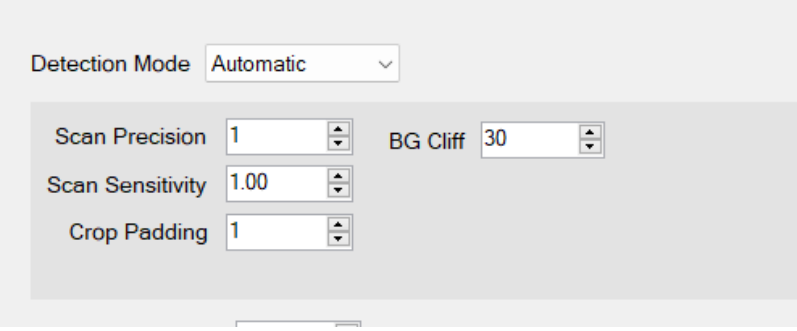
Radius

This will increase or decrease the size of the crop area circle.

X & Y

These will move the crop circle in 1 pixel increments along the X and Y axis.

Automatic Detection Mode



Scan Precision

As the software scans an image, it scans both horizontal and vertical lines. The precision of 1 represents a scan of every line of the picture. Increasing this number causes a coarser scan of the image. For example, if a precision of 4 is selected, the software will scan every 4th line (4 pixels apart). This can provide some performance increases while still offering reasonable detection.

Scan Sensitivity

This setting is the amount of light change required to trigger a detection point or edge (edge of the piece of brass). We scan each line and create an average value for the pixels in that line. It is compared against the previous averages and if it rises above the defined sensitivity value, that line will be marked as an edge. The scanner does its scan from left to right, right to left, top to bottom, bottom to top. 0 represents black and 255 is white.

Crop Padding

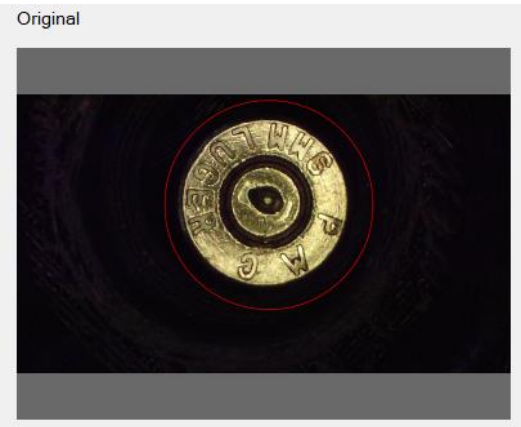
After we have detected the edges of the brass piece, we calculate the center and crop the image. The padding represents how much space to include outside of our crop or the black space which will be around our brass in the final image. It is recommended to have the least amount of padding possible.

BG Cliff

Background threshold determines the threshold at which a pixel is considered to be black or 0. This can be helpful to resolve issues where there is too much light or a gray background instead of a black background. A setting of 25 to 30 is generally recommended here.

Hybrid Detection Mode (Recommended)

Hybrid Detection mode simply combines the controls and functionality of Manual and Automatic mode. It is recommended that you select a large enough manual crop area to accommodate the positional changes from feed to feed. It is a good idea to set the area and then hit the feed button several times and pay attention to see that the brass is well within the crop area for each. See example below.

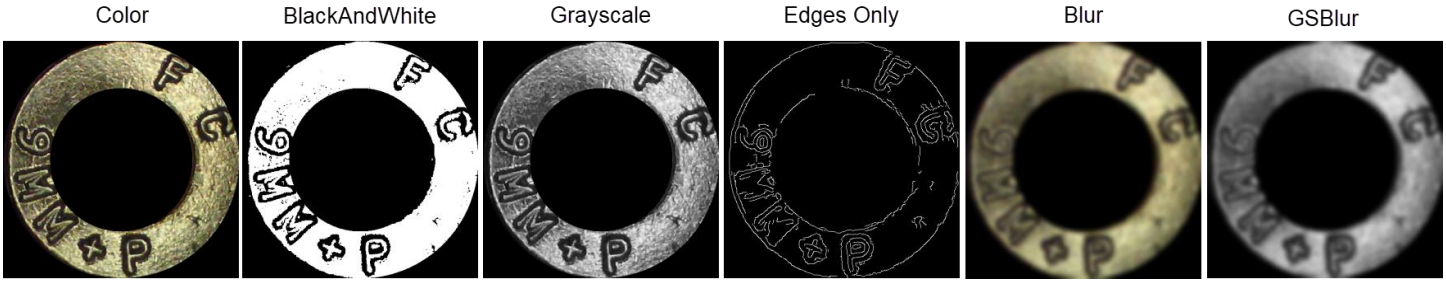


Processing Modes

The processing mode selection is used to provide additional image processing to the cropped images. Here is a summary of each mode.

- **Color** – This is the default mode and applies no color changes to the original image.
- **BlackAndWhite** – Not to be confused with Grayscale (GS), the mode only has 2 colors and a threshold to decide whether the pixel is to be converted to black or white.
- **Grayscale** – Desaturates the image so that it is rendered in grayscale.
- **Edges Only** – Detects and displays only the edges of the image.
- **Blur** - Adds blur to the colored original image.
- **GSBlur** - A combination of grayscale and blur

Here is a visual comparison of the different modes listed above.



Processing Mode Configurations

BlackAndWhite

Threshold – The threshold at which a pixel will be converted to white. scale is 0-255.

Edges Only

Filter Low: Using hysteresis thresholding, any edge with a gradient magnitude lower than this threshold is automatically excluded from being considered as an edge.

Blur: The amount of blur to be applied before applying edge detection. This helps to rule out non-edges.

Filter High: Using hysteresis thresholding, any edge with a gradient magnitude higher than this threshold is considered a strong edge.

Blur

Blur Size – The area used for calculating blur. Generally, a range between 2 and 40.

Blur – The amount of blur to be applied.

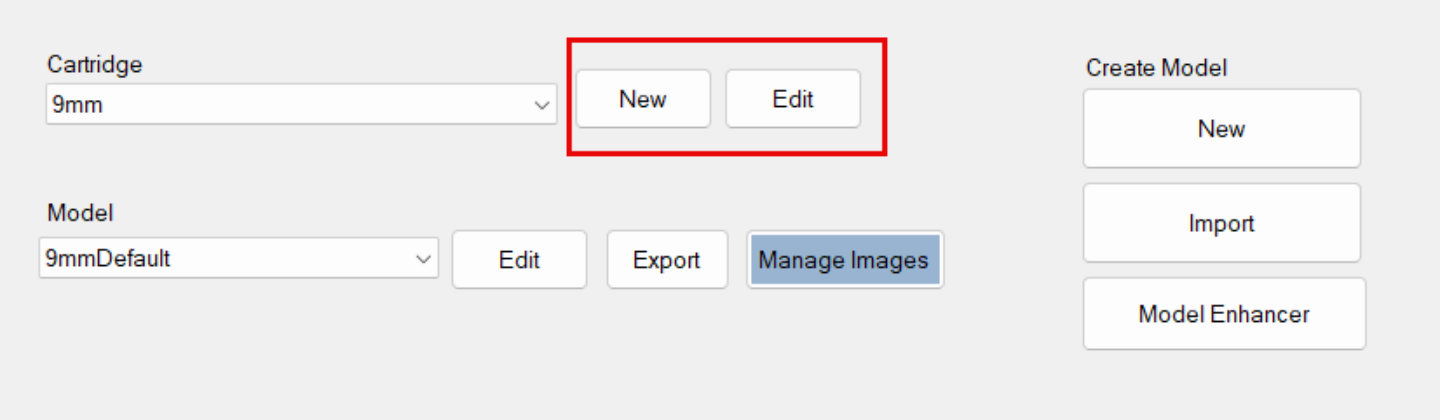
Models Screen

The **Models** screen is where you go to manage your cartridges and models. A cartridge is simply a high-level classification in which to organize subsequent models. For instance, by default there is cartridge named “9mm”. Within the 9mm cartridge, you can have many different AI Sorting models for different types of sorting of 9mm brass. You can create as many models as you need within a cartridge.

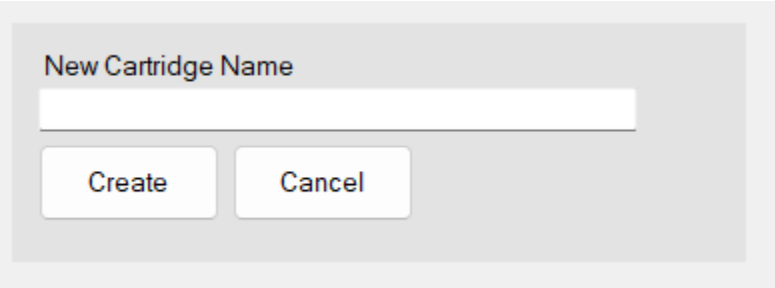
A model is a collection of images with headstamp associations (classifications) which are used to train a machine learning neural network. Every time a training is performed, a model file is created which represents the trained neural network. If the file already exists, it will be overwritten with the new trained model. If you add, remove, or reclassify images in the training screen, you will need to rerun the training to regenerate the model file.

Creating, Editing and Deleting Cartridges

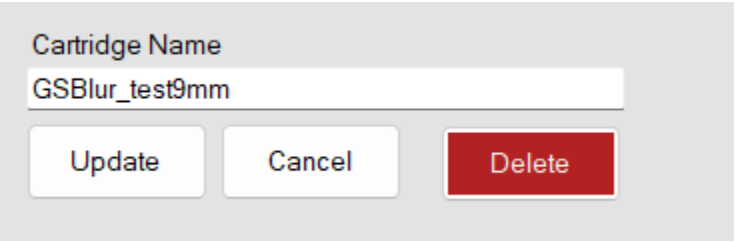
To add a new cartridge, you need to hit the **New** button next to the list of cartridges.



Give the new cartridge a name and hit the Create button.



To edit an existing cartridge, select that cartridge from the menu and click the **Edit** button. You will see a display similar to the one in the screenshot below:



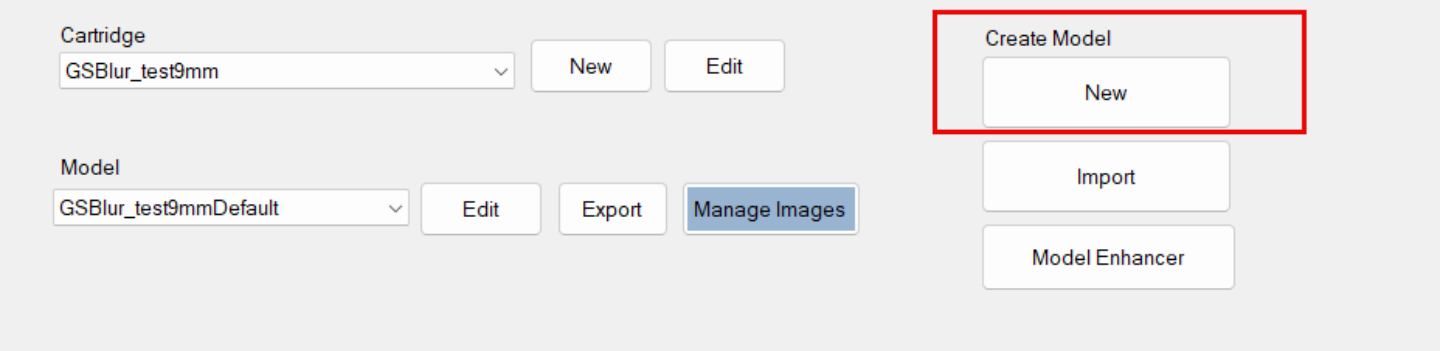
In the edit screen, you have the option to Rename the cartridge which is simply a matter of updating the Cartridge Name field and clicking the **Update** button.

In this screen you also have the option to delete a cartridge. Keep in mind, **models, images, training, etc associated with that cartridge, will also be deleted** so be very careful!

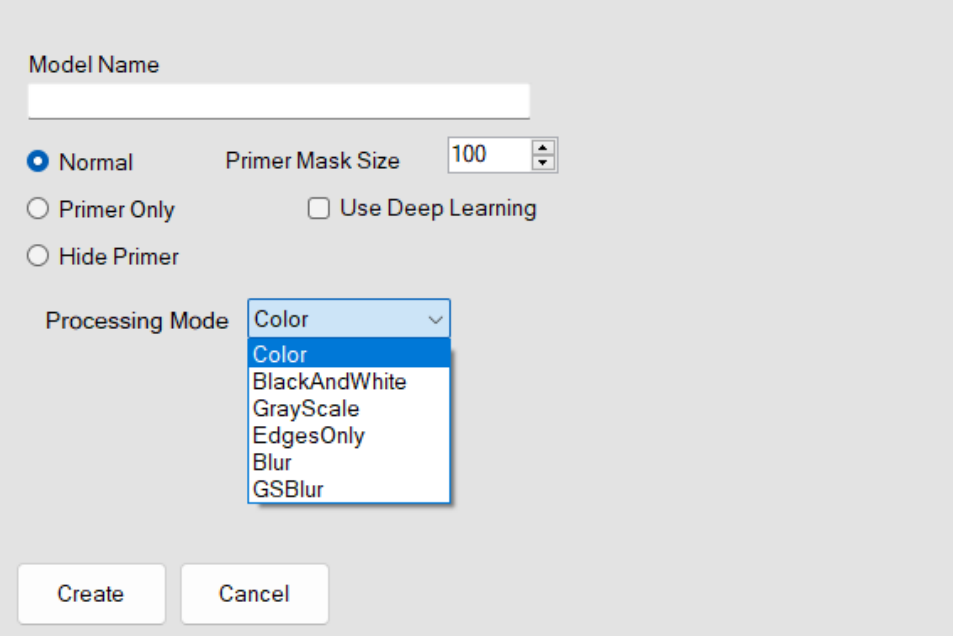
The **Cancel** button returns you to the previous display without saving any changes.

Creating and Editing Models

There are various ways to create a new model available in the **Models** screen but if you want to start with a new empty model, use the **New** button under the **Create Model** section.



This will display a creation screen like the screenshot below.



The first task in creating a model would be to give the model a name. The model's name should be short and concise and you should avoid special characters such as @#%*&(), etc. Here are some examples ("45_binary_largePrimer", "9mm_gsblur", "223_556_binary")

The name should provide enough information to identify the model.

Model Type (normal, mask, primer-only)

There are 3 radio buttons to select the type of model masking that is applied to your model.

- **Normal** – No masking applied.
- **Primer Only** – Uses the Primer Mask Size feature along with Image processing to crop the defined primer area. This mode is used to "zoom in" on the primer area and ignore the rest of the case headstamp which is useful for separating large and small primer brass which is common in some cartridges such as 45 Auto. *This requires image processing to be enabled in the configuration screen.

- **Mask Primer (Recommended)** – This is recommended for most models as it helps to improve the recognition of the headstamps by ignoring the primer area altogether. When this is enabled, a mask (black dot) will be applied to the primer area. *This requires image processing to be enabled in the configuration screen. Changes made to this setting will only be applied to newly captured images and will result in a mismatch for newly captured images. To apply this setting to already captured images, you should use the **Model Enhancer**.

Here is a representation of a resulting image from the 3 different types:

Primer Mask Size

This defines the size of the primer mask. For hiding a primer, generally a value of 135 works well here. For primer only, you may want to increase the size to 145-150. This value will also update the mask size value in the Image Processing **Fine Tuning** screen. Changes to this value in that screen will be applied to the model as well. It is important to know that changing this setting after you have already captured images can be problematic as this setting only applies during the capture process and newly captured images will not match those which were previously captured. To apply this setting to already captured images, you should use the **Model Enhancer**.

Processing Modes

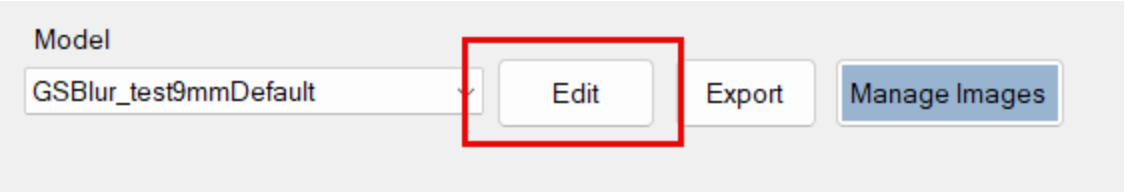
The processing modes were covered in detail earlier in this guide in the Image Processing section. Please refer to that for more information. If using a mode other than "Color", image processing needs to be enabled. Changes to this value in that screen will be applied to the model as well. It is important to know that changing this setting after you have already captured images can be problematic as this setting only applies during the capture process and newly captured images will not match those which were previously captured. To apply this setting to already captured images, you should use the **Model Enhancer**.

Use Deep Learning

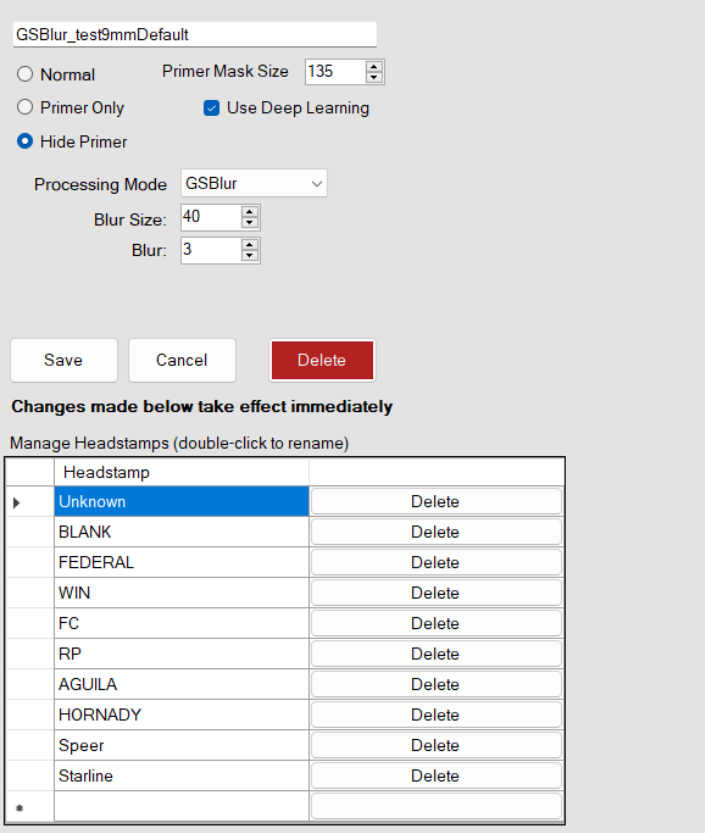
There are two types of deep learning used by this program and the "Deep Learning" label is a bit misleading as it should read "deeper learning". If the box is not checked, the program will use a TensorFlow model known as "Inception" which was created by Google and values low computational costs and trains much faster but may suffer in accuracy. When the Deep Learning is checked, we use the ML.Net image classification model created by Microsoft which takes much longer to train (time increases with image count) but tends to yield much better accuracy in recognition. The time to train a model depends very much on the performance of the computer and a model with 10K images could train in just a few minutes on a fast computer but take a couple hours on a slower machine.

Editing a Model

To edit an existing model, click the **Edit** button next to the selected model.

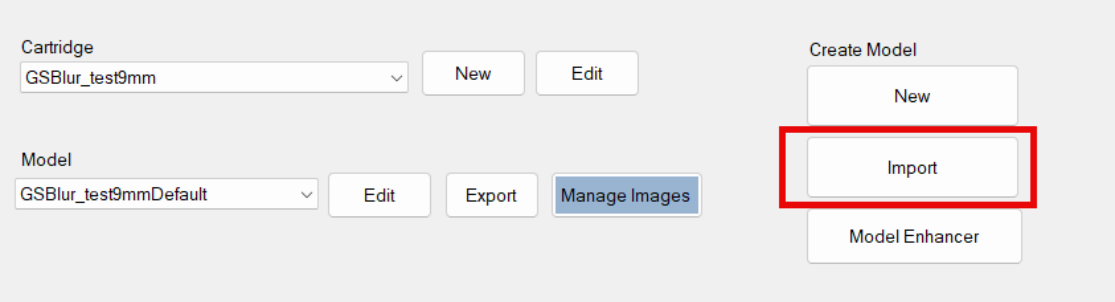


The **Edit** screen looks very similar to the model creation screen but has one additional feature which allows you to create, rename or remove headstamps which have been added to the model. In addition, you can sort the headstamps display by clicking on the column header.

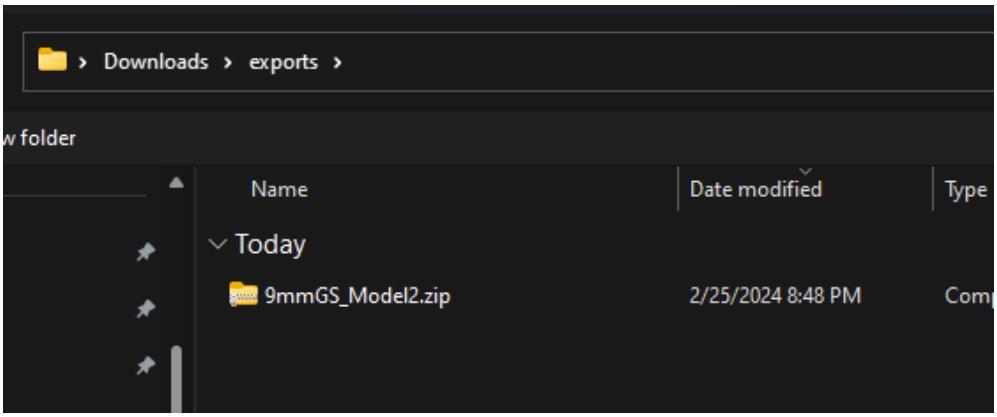


Import

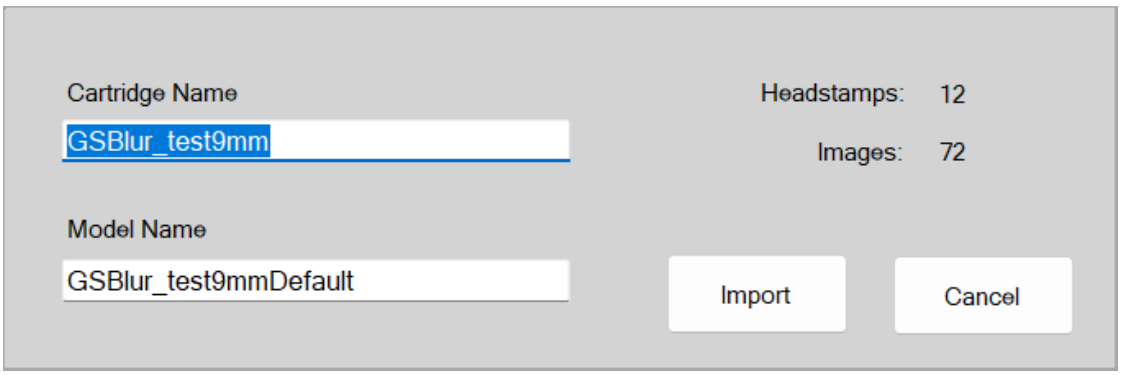
The import feature can be used to import an exported or shared model. The model can be one which was created on a different system and exported to an export file.



After hitting the **Import** button, a file dialog will open, and you can browse to the export file which you intend to import.

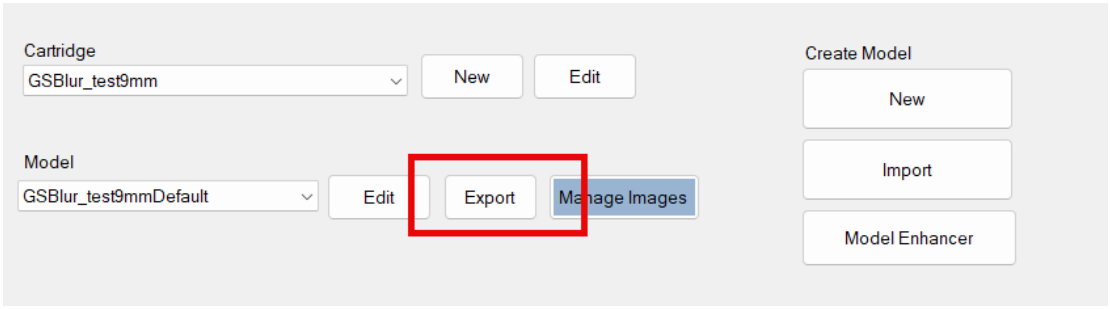


Once you have selected the file you wish to import, you will see a summary screen where you can change the name of the cartridge and model to be imported. If the cartridge name already exists, the model will be associated with it otherwise a new cartridge will be created as well.

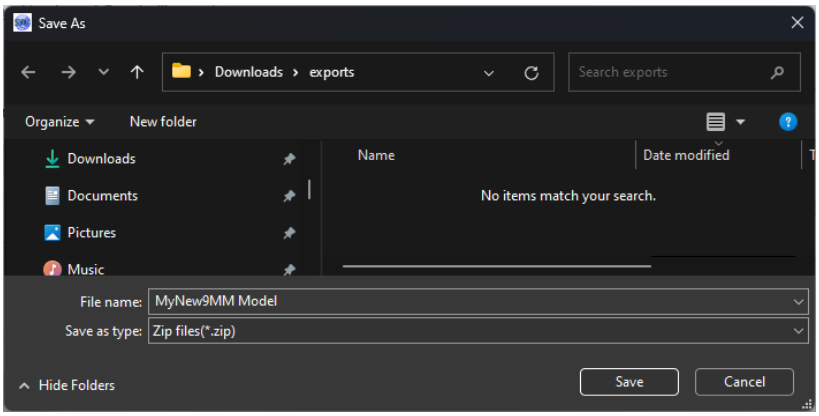


Export

The export feature is used to create an importable model file containing both the model and the training images. The model and images are compressed into a zip file along with a manifest file which contains information about the model. That zip file can then be shared or saved as a backup of that model. To export a model, simply select the model and click the export button.

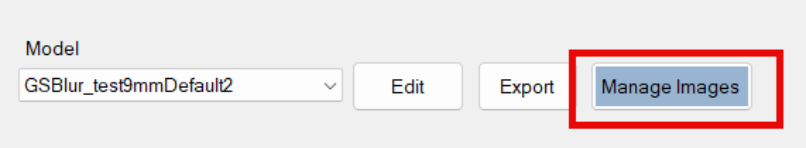


A file dialog will open which allows you to select the location and name of the exported file.



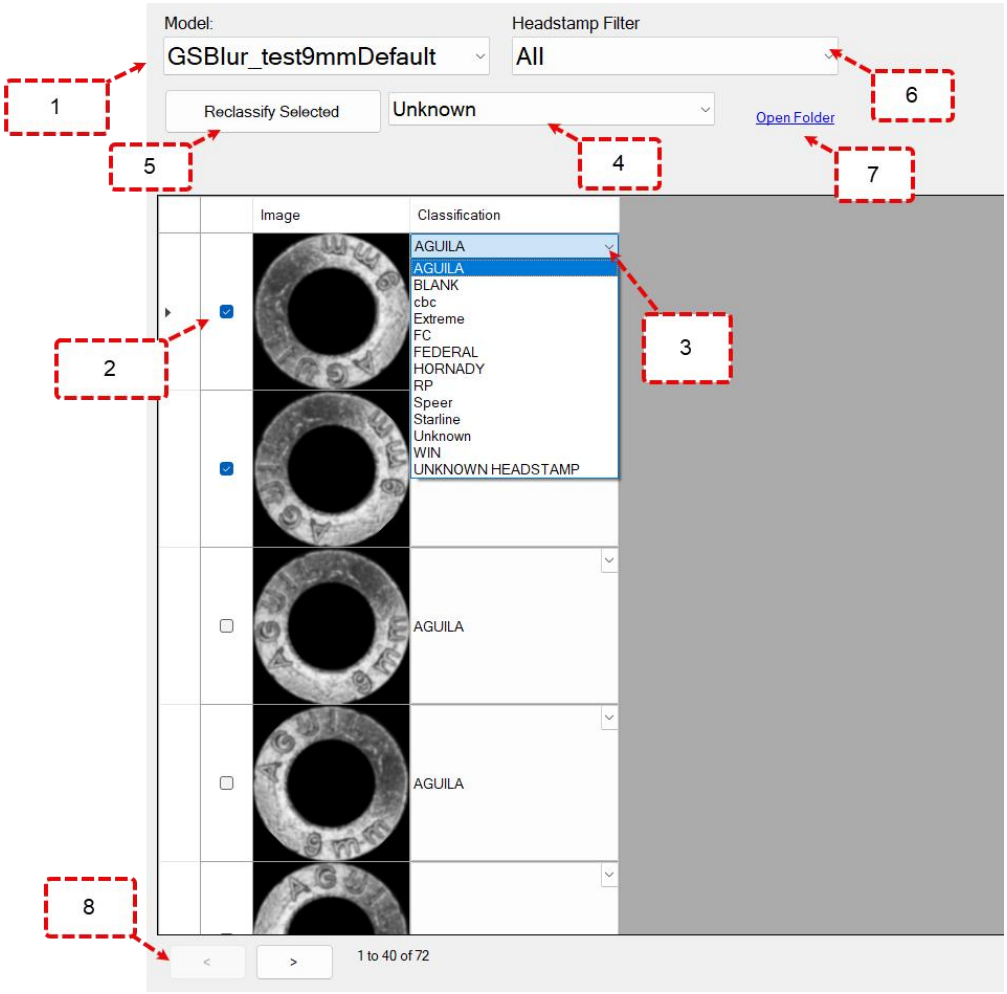
Manage Images

The **Manage Images** screen is where you can go to inspect the training images for your model. This screen also gives the capability to change the classification for an image if one was misclassified.



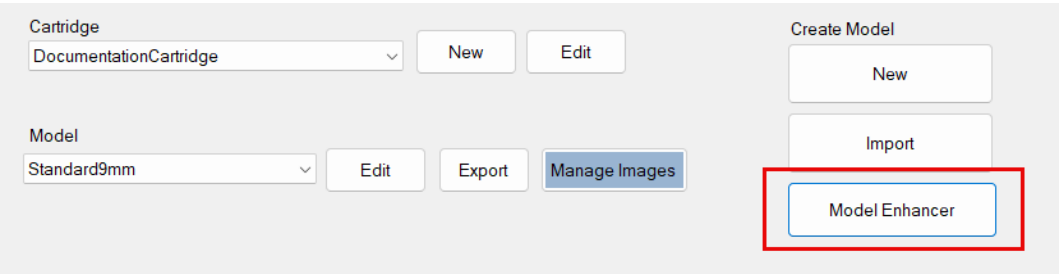
The following numbered items correspond to the numbered labels in the screenshot below outlining the different functions of the **Manage Images** screen.

1. Dropdown menu which indicates the currently selected model.
2. Checkboxes next to the image row allow multiple items to be selected for reclassification. When reclassifying multiple items, you need to use the **Reclassify Selected** button and dropdown (4 & 5)
3. The dropdown menu used to reclassify a single image row. (the currently selected row)
4. Used in conjunction with the **Reclassify Selected** button to select the classification which will be applied to the selected items.
5. Changes the classification on the selected items to the one selected in the menu (#4)
6. The headstamp filter menu selects which headstamps will be displayed in the grid below.
7. The **Open Folder** link opens the training image file location using the operating system dialog. This can be helpful if you want to do bulk operations manually.
8. Grid paging controls. With a page size of 40 items, these arrows allow you to page through the images.



Model Enhancer

You can access the model enhancer from withing the **Models** screen. First select the model you want to work with and then click the **Model Enhancer** button.



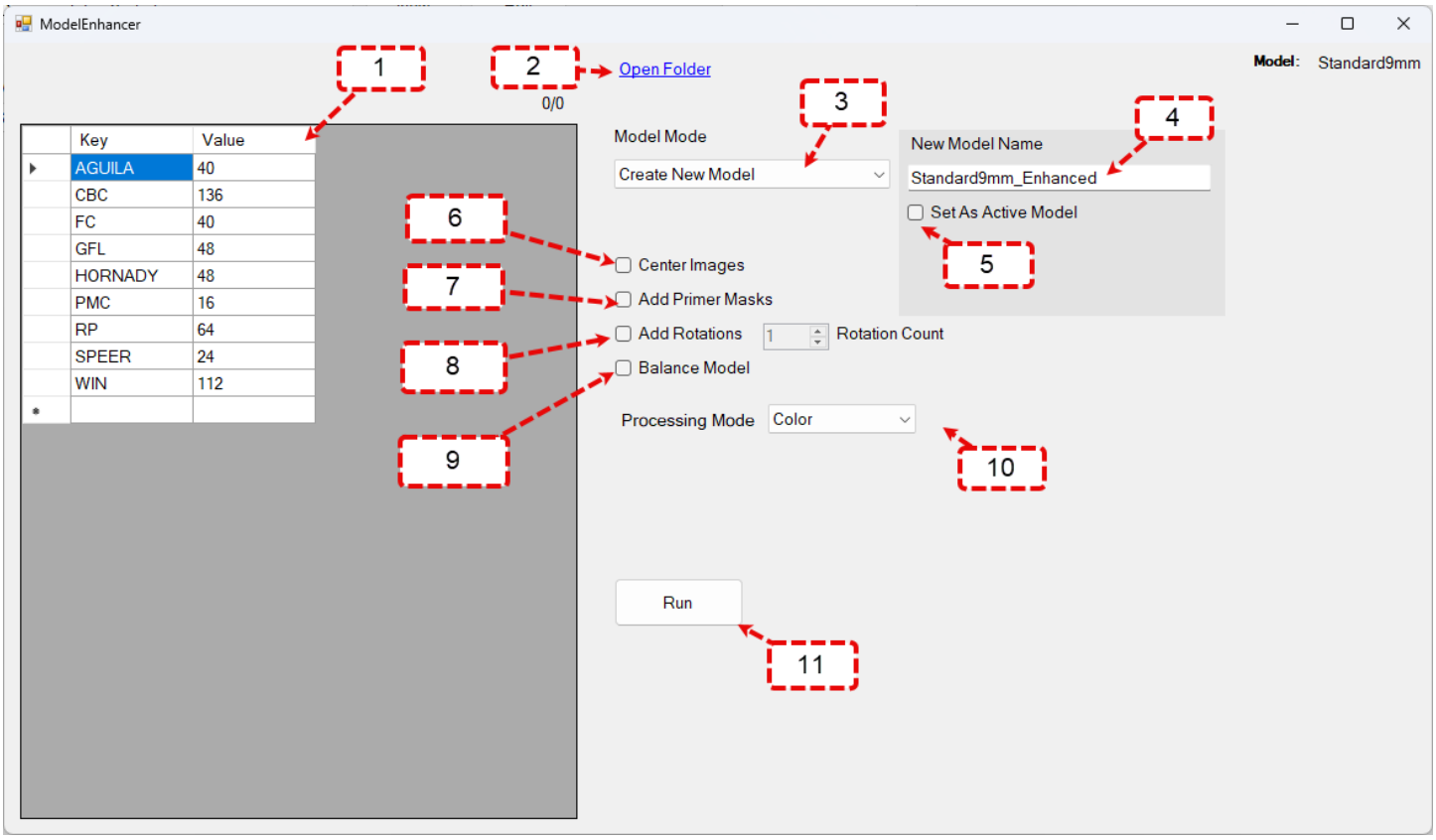
The Model Enhancer utility was created to be a multi-purpose tool with functions to “enhance” a model. The enhancements can be applied to an existing model or can be applied to a clone of the existing model thus creating a new model and leaving the existing model unchanged. It is highly recommended to create the new model whenever possible as it preserves the existing model and allows you to “roll back” or discard the new model if the changes ended up not working as well or being less than desired. Multiple models can be created based on a “base” model which allows for a/b type testing between the different models.

The following numbered items correspond to the numbered labels in the screenshot below outlining the different functions of the **Model Enhancer** screen.

1. The headstamp grid contains the headstamps and images counts for each that are present in the model.

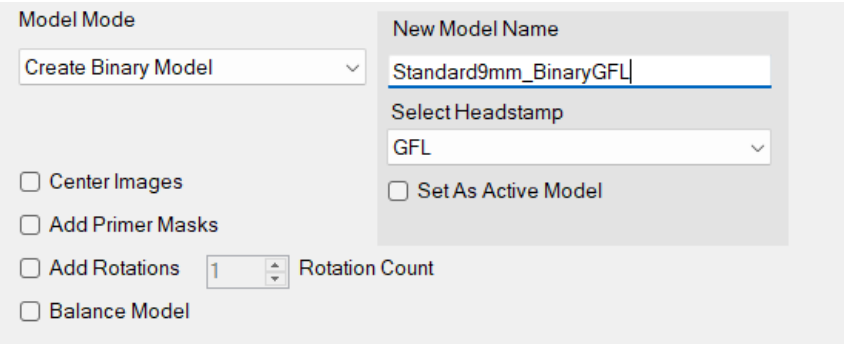
2. The **Open Folder** link opens the images folder on the file system for the current model.
3. **Model Mode** menu selects whether the selected **Run** operations will be performed on the current model or to a new model which starts from a clone of the current model.
4. If "Create New Model" is selected in #3, the **New Model Name** field will be the name of the newly created model.
5. If selected the newly created model will be set as the current and active model in the system, else the currently selected model will remain active.
6. **Center Images** – Using automatic detection, if this option is selected each image in the training set will be processed and centered. This can be useful if you have excess padding around your images and want to add consistency. Because the processing here is automatic, it is recommended to visually inspect the resulting centered images in thumbnail view in the operating system images folder (see #2)
7. **Add Primer Mask** – If selected, a mask will be placed over the center of the image with the primer mask size defined in the selected model. Note the mask is a black circle that is blindly placed in the center of the image. If your images are not already centered, this will yield poor results.
8. **Add Rotations** – This function will add the specified number of rotations for each image in the model. Degree of rotation for each image is based on the 360 divided by the **Rotation Count.**
9. **Balance Model –** This feature is designed to ensure that each headstamp classification has the same number of images. In testing there seems to be a strong correlation between accuracy and having a balanced image set. It performs this balance operation by adding rotations to the images in each classification in the model until it has the same number of images as the largest classification set. In the screenshot below, CBC with a count of 136 would represent the largest set. In this example, roughly 2 rotations would be added to each image in the Aguila set bringing the number to 120 and then 1 additional rotation would be added to the first 16 images until the 136 number has been reached.
10. **Processing Mode –** This menu is the same control set that is seen in Model Create/Edit screen and the Fine Tuning screen. See that section of this document above for more details on the individual modes and settings. In this context, the images will be processed with whichever processing mode is selected. This can be useful if you want to change all your images to a new mode such as Grayscale. If you already have a good model but are seeking to improve it, you can clone the model and use one of these modes. This will allow you to compare the accuracy of your existing model vs the one newly created with the new color mode.
11. The **Run** button begins the model enhancement operations. The order of operations is as follows:
    1. If **Create a New Model** is selected, a new model will be created and then all of the images and headstamps will be cloned and associated to the new model.
    2. Image Centering (if selected)
    3. Add Primer Masks (if selected)
    4. Add Rotations (if selected)
    5. Balance Model (if selected)
    6. Apply Color mode (if different than base model)

    The progress of the run operation will be seen in a progress bar which is above the headstamp grid.



Creating a Binary Model

The Model Enhancer also contains a feature to create a binary model based on an existing model.



A binary model is a model with two classifications (EG: hotdog, not hotdog). When binary is selected as the mode, you will see an additional dialog which is a menu of all the classifications for that model. You must select the classification you wish to create the model based on. To create the model, the system will use the count of the currently selected headstamp images and select a balanced set of images from all the other classifications so that the total counts between the two classifications are equal. (GFL, not GFL)

The Train Screen

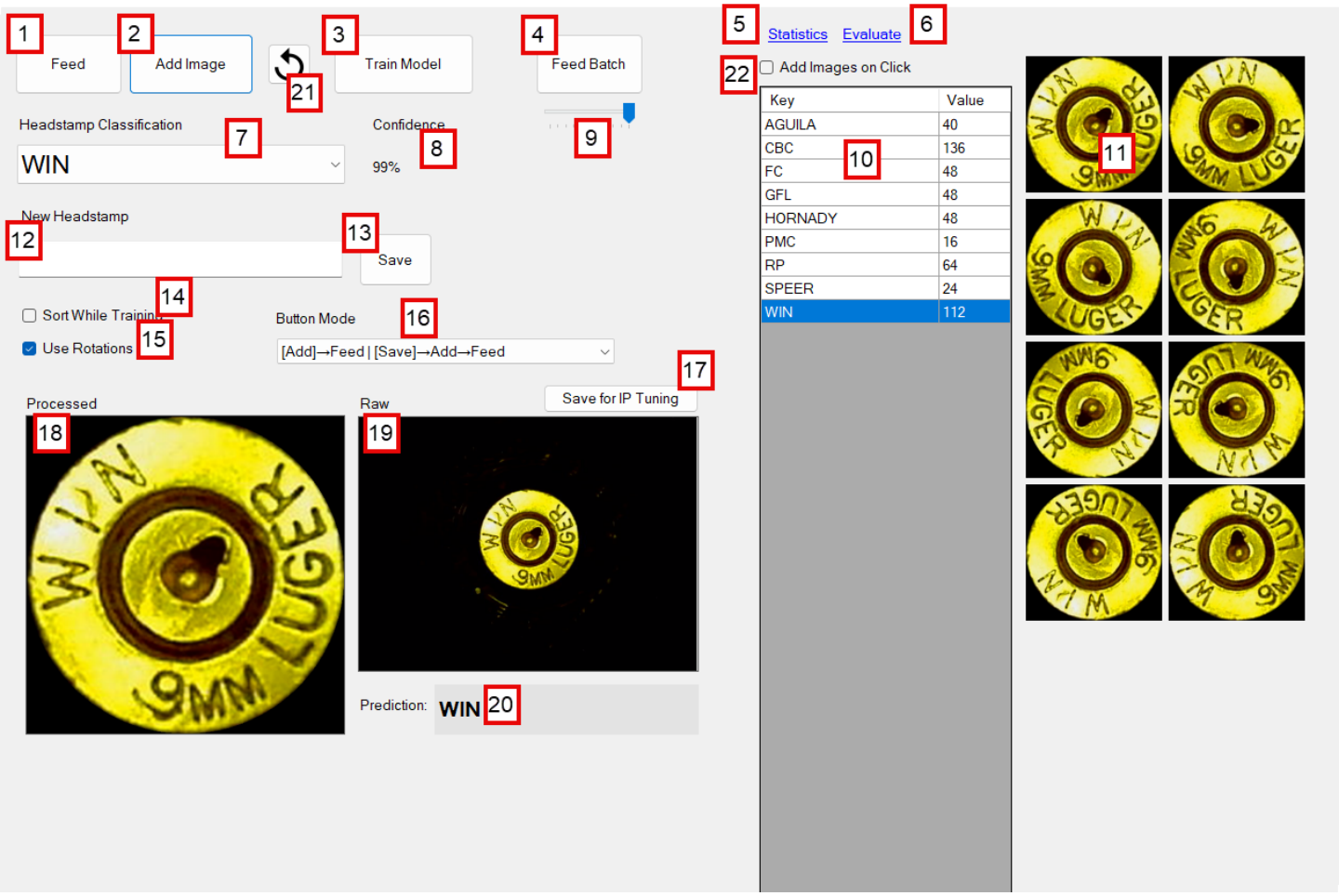
Training a Model (Train)

The process of training a model consists of a few basic steps:

- Capture an image (and optionally, its rotations)

- Classify the image (assign a headstamp)
- Save the image(s) to the model's images folder.
- Repeat the previous steps until enough images have been captured and classified. To perform the machine learning step, you need a minimum of two different classifications.
- Train the Neural Network (Train Model).

Controls



Here is a brief description of each of the controls on the training screen and their function.

1. **Feed** – This causes the feed wheel to move one position. It ignores the status of the proximity sensor and performs a forced feed. Once the feed is complete, an image is captured and displayed in #19, #20, #11 (if use rotations #15 is enabled). Feed does not "save" images or modify the training set in any way (even with automations enabled). If you get a bad or empty image, use Feed to move to the next case.

2. **Add Image** – This button "saves" the images to the training folder with the selected headstamp classification (#7 and/or #10)
3. **Train Model** – This button initiates a training sequence where the images are processed through the neural network and a machine learning model is created. This can take anywhere from a few minutes to many hours depending on the number of images in the model's training folder.

4. **Feed Batch** – Batch feeding is an automated option for adding many images of the same classification to a model quickly. For instance, if you have 50 pieces of brass with a classification of CBC and want to automatically add them, you will clear your feed system and then add those 50 pieces in so that only those

50 will be fed. Then you would change the classification value (#7) to CBC or (if CBC doesn't exist yet, create it using #12). Once the classification has been set, you can press this button to begin automatically feeding and saving the images. The speed control for this function is #9.

5. **Statistics –** You will not see this option until the model has been trained once. The statistics screen provides some information about the model and is covered in more detail below.

6. **Evaluate –** This is not available until the model has been trained once. It launches a utility which can be used to find items you may have accidentally misclassified. It can also be used to find weaknesses in the models' training and give you an idea of which headstamps need to have more training images. The usage of this utility is covered in more detail below.

7. **Headstamp Classification Menu –** This is a list of all headstamps in your model. After an image is captured for a new case, you will use this menu (or optionally the grid in #10) to classify the image (and its rotations) before adding them to the model using the Add button (#2). *Note: after a model has been trained using the **Train Model** button, each time an image is captured, the software will attempt to automatically classify the image based on its training. It will automatically select the headstamp from this menu but will often be incorrect early in the training cycles but will improve as you add more images and retrain the model.

8. **Confidence –** This is often misunderstood as accuracy, and it is important to have a proper perspective on this value. It is a percentage-based confidence level given to a prediction based on what the model has been trained on. It can be highly confident and incorrect at the same time. For example, if you only added one classification to a model and trained it (not currently possible but just an example), because it only knows of one classification, it will be highly confident that every piece of brass it predicts will be that one classification. If you only have two classifications, it would be highly confident that it has selected the best match out of the two options. The number of unique headstamps in a model will also affect the confidence level but not the accuracy of. For instance, if you have 100 different headstamps in a model, and it predicts for 1 case, it is very common for it to predict correctly with low confidence. In this example if it had a confidence of 40%, it means that the 99 headstamps share the other 60%. You may end up with a confidence ranking like: Fed: 60%, CBC: 16%, Win: 3%, FC: 1%, LC: 1%, etc.

9. **Batch Classification Speed Control –** This slider determines how quickly to feed the batch when using batch classification.

10. **Headstamp Classification Grid –** This table gives a quick view of the headstamps in the model and how many images exist for each. It can also be used to classify images as an alternative to menu in #7.

11. **Image Rotations Preview –** If image rotations are enabled, this panel provides a preview of the rotations.
12. **New Headstamp Field –** As you are training your model, when you encounter a new headstamp, you can add it to your headstamp list by typing the headstamp (ensure unique) and hitting the **Save** button (#13). This will add it and select it in the headstamp menu #7.

13. **Save Headstamp – Adds** the headstamp classification option specified in #12 to the model (see #12)

14. **Sort While Training -** If enabled, cases will be sorted based on their classifications into the bins specified in the **Run** screen configuration.

15. **Use Rotations –** If checked, when a new image is captured, a number of rotations will be created. That number is based on the value set in the Image Processing section of the **Configuration** screen. *Note: This option will only be available if **Enable Image Processing** is checked in the **Configuration** Screen

16. **Button Mode –** This menu lists a set of automation configurations for the buttons on the training screen. Here is a brief description of each:

    Standard – No Automation, each button must be pressed to perform its action.

    [Add]->Feed – After the **Add** button is pressed and images have been added, a **Feed** occurs automatically (as if the feed button was pressed)

    [Save]->Add – When a new headstamp is added and the Save button is pressed, it will classify the image with that headstamp and add it to the images folder as if the **Add** button was pressed.

    [Save] ->Add->Feed – In addition to the mode above, it will also perform a **Feed** operation.

    [Add]->Feed | [Save]->Add-> Feed – This activates the above-described modifications for both the **Add** and the **Save** buttons and is the recommended mode as it is the most convenient.

17. **Save for IP Tuning –** This button will save the original (unprocessed) image to the Image Tuning folder (typically at: C:\Program Files\SJSeth\AI Brass Sorter\training\images\tuning). Images saved to this folder can be loaded in the Image Processing Fine Tuning screen. (see Image Processing)

18. **Processed Image Preview –** This image is a preview of the fully processed image. This can be used to get a better view of the headstamp so that you can classify or reclassify the image.

19. **Raw Image Preview –** This image is the unprocessed image as detected by the camera.

20. **Headstamp Prediction –** Once the model has been trained, it will automatically try to predict each captured image. You can compare this value against the actual image to ensure they match before adding the image to the training set.

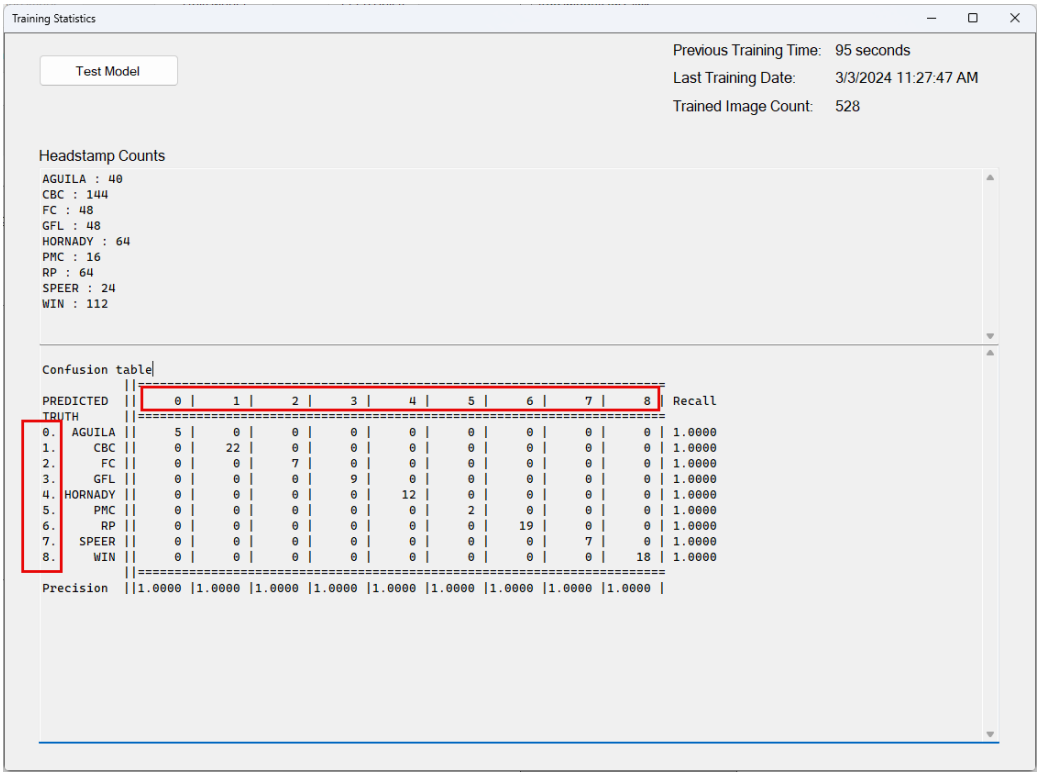
21. **UNDO –** This will remove the last added image set from the images folder. If you accidentally misclassify and add the image, this will UNDO that mistake.

22. **Add Images on Click –** This checkbox "enables" the headstamp grid to allow it to be used for classification. When unchecked, the classification grid has no clickable function.

Model Statistics

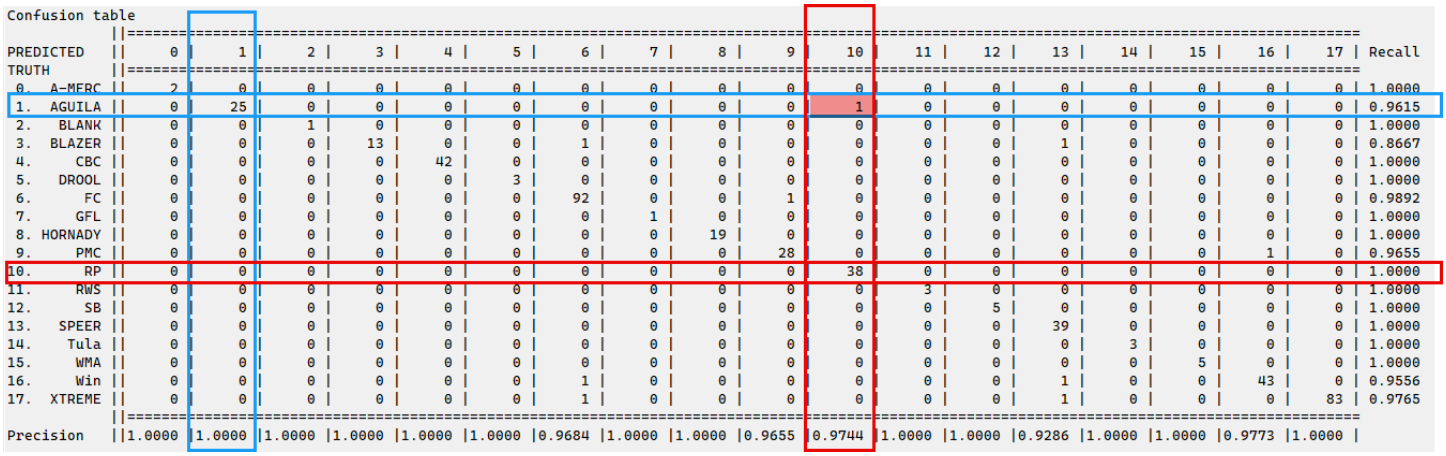
The model statistics utility provides some basic statistics about the model from the last training period. This includes how long it took to train the model and how many images were present in the training. In addition, you can perform a test of the model to generate a confusion matrix. The matrix is generated by taking 15% of the images for each headstamp and running predictions for them. The numbers on the top of the matrix correlate to the numbered and labeled headstamps on the right as seen in red below.

The columns represent each available headstamp/classification in the model, the rows represent how the images were predicted by the model.



The first example above is a best-case scenario where all cases were predicted correctly and the resulting precision and recall was 100% (1.0) for each headstamp.

In the following example, where you can see more discrepancies in the predictions:



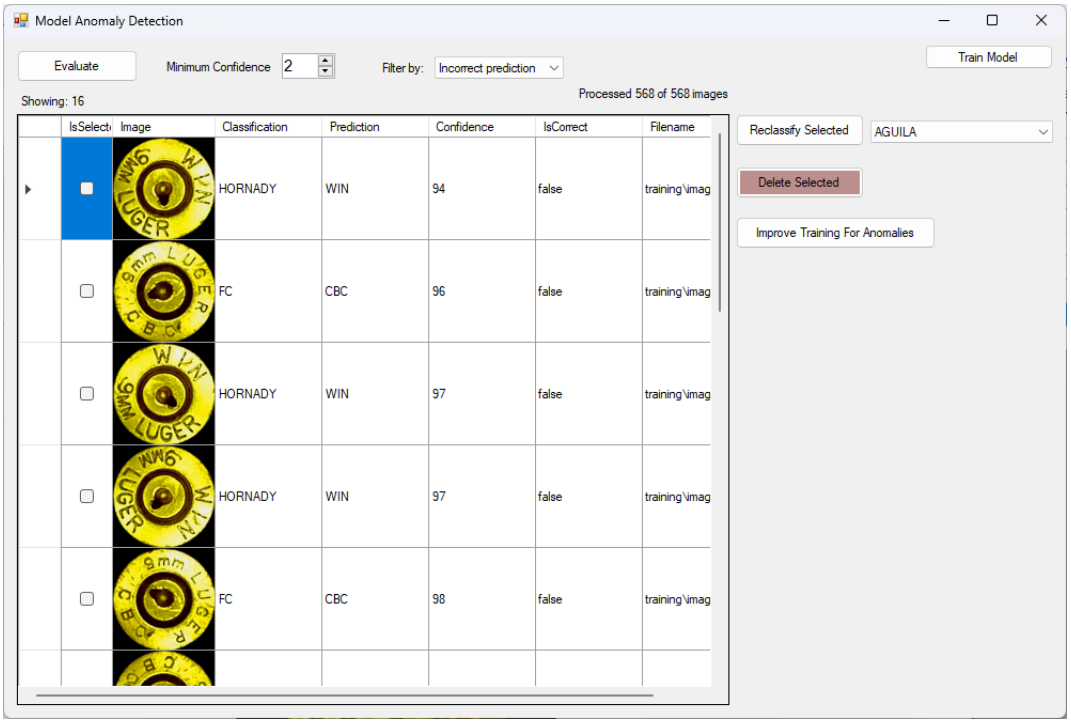
Precision measures the accuracy of positive predictions, while ***Recall*** measures the completeness of positive predictions. To clarify further, when we examine the model above, we can see that *AGUILA* has 100% precision

and 96% recall and this means that after sorting, we can be confident that 100% of the brass that went into the Aguila bucket is stamped *Aguila*, however only 96% of all the *Aguila* brass went into the *Aguila* bucket since 4% went into the *RP* bucket. Inversely, 100% of RP brass went to the RP bucket but there was also 4% of Aguila brass there as well.

It is important to understand that these numbers are much higher than real world testing as the images being used for the matrix test were the same ones used to generate the model. Still, it gives us a basic idea of how well our model is performing and where some potential problems might be. In the example above, it would be a good idea to check the images for those classifications which are lower to ensure they are classified correctly. It might also be a good idea to add more training images in those areas where there was confusion.

Evaluation / Anomaly Detection Utility

This utility is available in the training screen as a link title "**Evaluate**" after a model has been trained. The purpose of this utility is to help one locate images that may have been misclassified and also can help expose weakness in your model training. To begin, you must hit the evaluation button. As the system evaluates the images, those which meet the criteria specified will begin to appear in the grid. In the filter by column, there are three options which are *Incorrect Prediction, Confidence or Both*. Incorrect Prediction checks to see if the prediction matches the actual classification specified by the user during training. In the image below, you can see the user incorrectly specified the classification for some of the images. In this situation, we can select the checkbox next to an image and then use the drop-down menu on the right to select the correct classification. After selecting the correct classification, you need to click the "Reclassify Selected" button. You can do multiples at the same time so in the example below, one would check the boxes next to each of the "WIN" pictures and reclassify all of them as WIN.



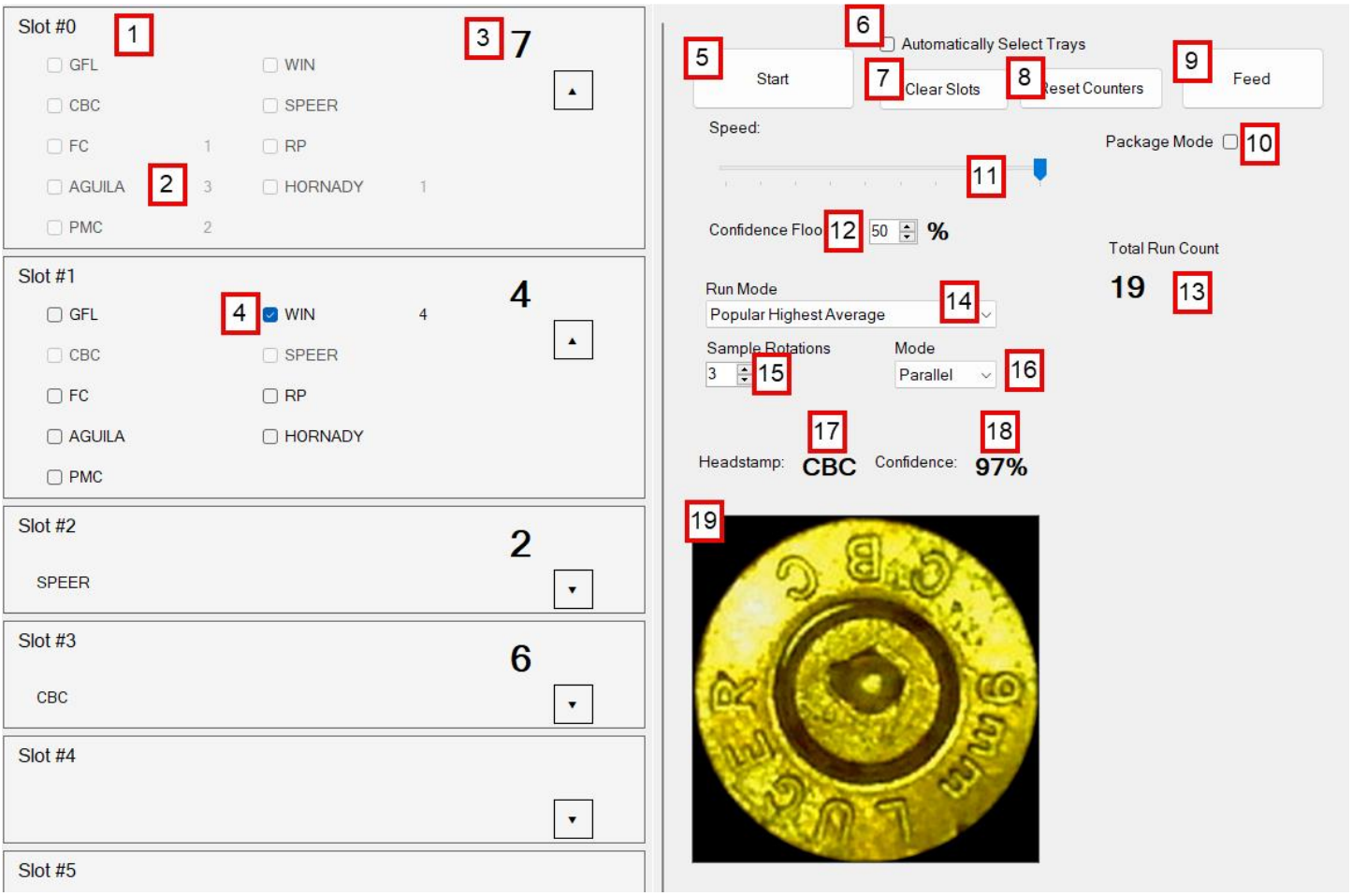
If all of the images are classified correctly, the utility can be used to find those images which fall below the confidence threshold specified. This can be helpful for letting you know which headstamps need more training. **If the classifications are correct but the confidence is lower than desired**, you can use the "Improve Training for Anomalies" which simply adds 5 more rotations for each image in the grid to the training. After performing this step, you will need to train the model before seeing any benefit. You can use the **Train Model** button on this screen or on the Training screen.

The Run Screen

Overview

The Run Screen is where you go to sort your brass. In this screen, you will select which slot where you want each headstamp to go. Unselected headstamps will go to the catch-all slot which is Slot #0. This slot cannot be configured.

Controls



Here is a brief description of each of the controls on the run screen and their function.

1. **Catch-All Slot (Slot #0) –** The first slot in the list is the catchall slot. Its function to serve as a place for all cases to go which are either not bound to another slot or are below the required **Confidence Floor** setting (#12)

2. **Headstamp Counters –** In each slot configuration, for each headstamp there is an individual counter which is incremented whenever a case is dropped into that slot.

3. **Slot Counter –** Each slot has a counter which is incremented when any case is dropped into that slot. It serves as a "Total" count for that slot.

4. **Headstamp Checkbox –** This box must be checked to bind a headstamp to a slot. In the standard sorting mode, a headstamp can only be bound to one slot at a time. In package mode (#10), a headstamp can be

bound to multiple slots.

5. **Start Button –** This button starts the sorting process. Once the button is pressed, it becomes a "Stop" button which serves to stop the sorting process.

6. **Automatically Select Trays –** When this is selected, the sorter will automatically bind an unbound headstamp to the first unbound tray. This will occur in a 1:1 fashion until all headstamps or all slots have been a headstamp binding. For example, if a CBC headstamp is detected but CBC has not been checked in any slot config, it will find the first slot which has no checkboxes checked and check the CBC box in that slot.

7. **Clear Slots –** This button clears the slot bindings.

8. **Reset Counters –** This button clears all the counters on the page including the headstamp, slot and total counters.

9. **Manual Feed –** This button is a manual "force feed" button and can be useful when you encounter an upside-down case which doesn't trigger the proximity sensor. Also, at the end of the run it can be used to feed out the last 3 cases.

10. **Package Mode –** When checked the system switches from sorting mode to package mode. Package mode is designed to count a certain amount of brass into each slot. This is covered in more detail below.

11. **Speed –** The speed control allows you to slow down the system. This can be helpful if you are outrunning your brass feeder. It is also useful if you wish to have a bit of extra time to manually inspect the predicted results.

12. **Confidence Floor –** This value indicates the minimum confidence that a headstamp prediction must have to be sorted. Any brass with prediction lower than this confidence rating will be sent to the catch-all slot.

13. **Total Run Count –** This is the total number of cases which have been sorted since the last counter reset.

14. **Run Mode –** The sorter has 4 prediction modes which define the technique used to predict the headstamp. These are:

    Single Image Highest Confidence (default) – This is the fastest run mode and uses a single prediction to classify the headstamp.

    Multi Image Highest Confidence – When selected, the system will create a number of sample rotations (specified in #15) and predict each rotation. It will then select the prediction from the rotation with the highest confidence rating.

    Highest Average Confidence – It will average the confidence ratings from the sample rotations and select the rotation with the highest average. For example, given 4 rotations and results like: FC: 70, WIN:75 FC:72, WIN:50 the system would select FC has the prediction with a prediction average of 71.

    Popular Highest Average – It will average the confidence ratings from the sample rotations in addition to counting the number of predictions for each group. The largest group with the highest rating wins. For example, given 6 rotations with results like: FC: 50, FC:51 FC:55, WIN:60, WIN60, CBC:95, the system

would select FC because it is the most popular in that it occurs 3 times. In this example if we removed one of the classifications for FC, then WIN would be the winner since the group size (population) for FC and WIN are the same and WIN has a higher confidence rating.

15. **Sample Rotations –** The number of rotation images to create for each prediction. This option is not available in *Single Image Highest Confidence* run mode (#14)

16. **Prediction Mode –** When predicting multiple rotations we have two modes. Serial mode predicts them one at a time (one after another) and Parallel mode predicts them all at the same time. Parallel mode will typically run faster than serial mode when running on a faster computer with many cores and memory. In Parallel mode, there will be a slight delay when starting the sort as it needs to create the number of processing threads based on the number of sample rotations selected (#15).

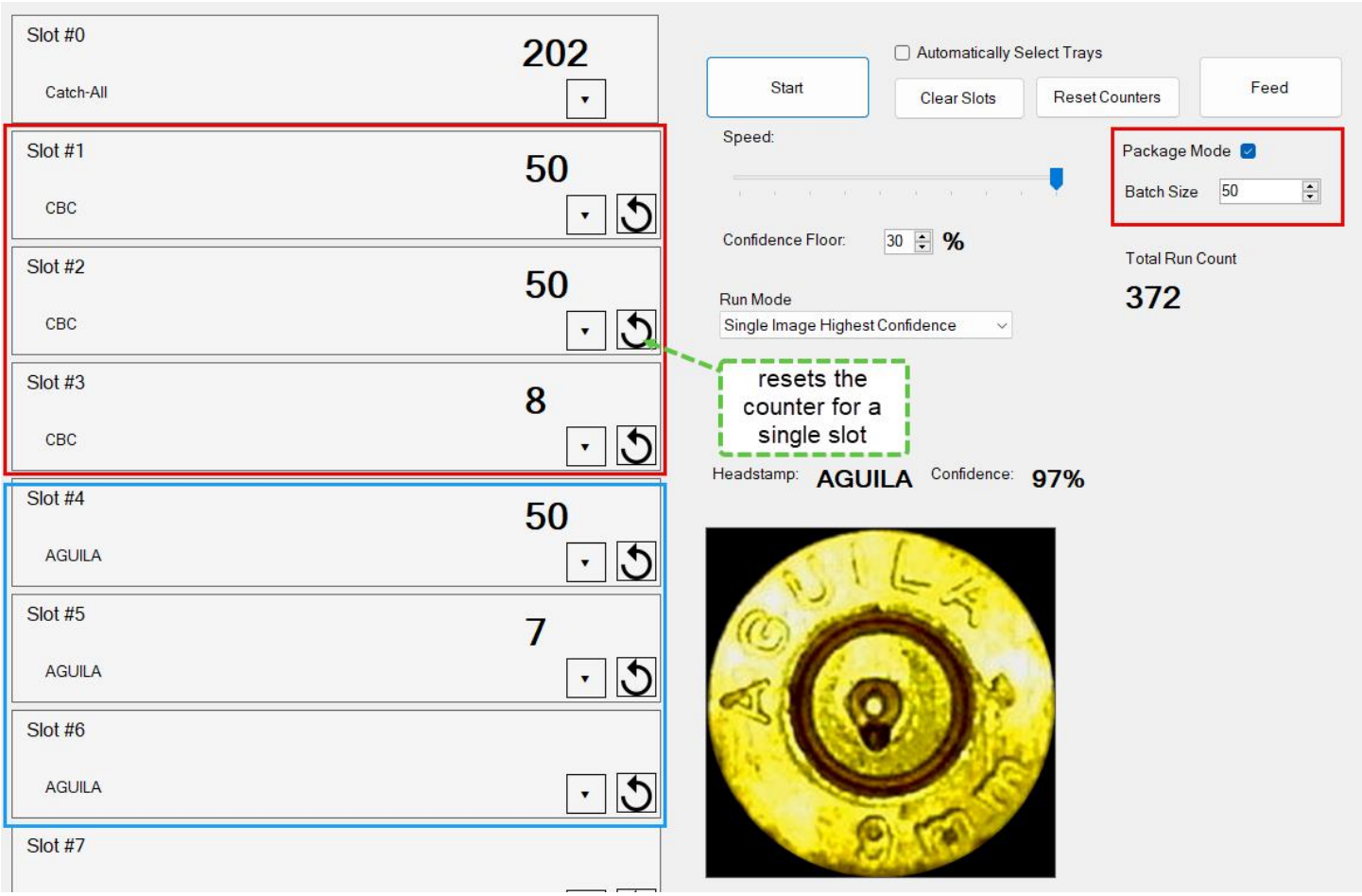
17. **Headstamp Prediction –** This indicates which headstamp was predicted for a case.

18. **Confidence –** Indicates the confidence for the headstamp prediction.

19. **Processed Image Preview –** An image preview after all image processing has been applied.

Package Mode

In addition to sorting by slot, you can also use the system for sorting batches of brass for packaging. You simply need to enable package mode and specify the *batch size*. In package mode you can bind one or more headstamps to multiple slots. The system will fill each slot one at a time. When a slot has reached its capacity, the system will pause briefly and sound an alarm (3 beeps) to alert you before moving on to filling the next slot.

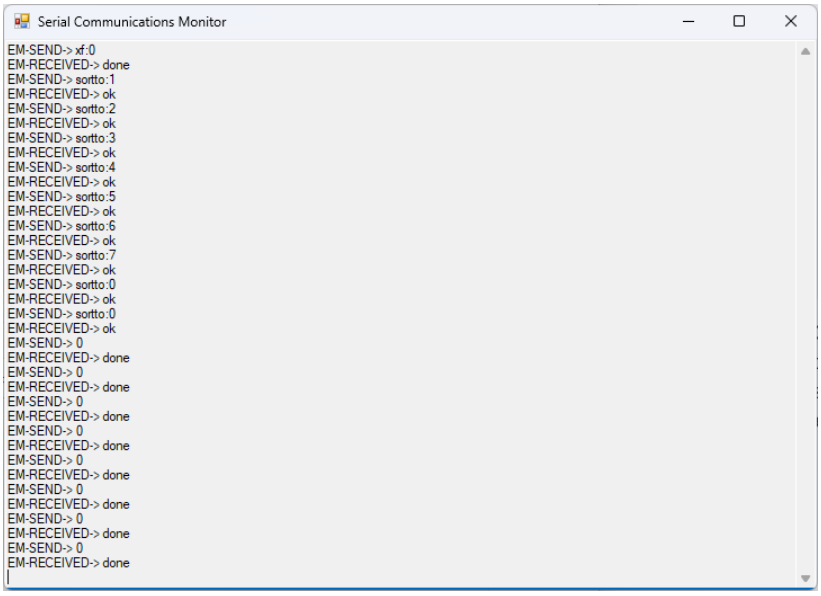


The screenshot above shows the system in package mode and configured to package two headstamps (CBC and AGUILA) in packages of 50. As you can see, two of the 3 bound slots for CBC are full and one of the Aguila slots is full. In this scenario, if monitoring the system, one could empty the bins for slot 1 and 2 into packages (boxes or bags) and then hit the reset button next to each slot. This will reset the counter for the slot making it available to package another batch. This can be done without stopping the system for continuous operation.

Advanced / Hidden Features

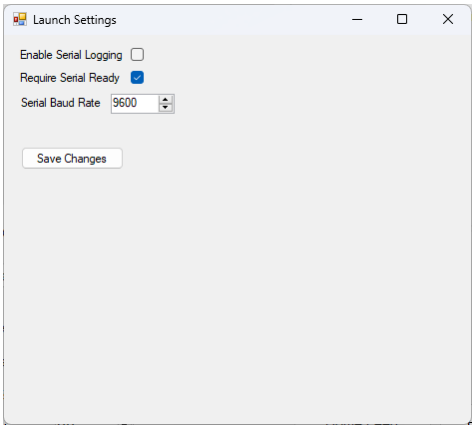
Serial Communication Monitor

You can launch a serial communication monitor using the keystroke combination **CTRL + K** which opens a window giving a report of incoming and outgoing serial messages between the app and the sorter. This can be seen in the following screenshot. Messages marked with SEND are from the software to the Arduino and those with RECEIVE are the responses from the Arduino to the software.



Launch Settings

The Launch Settings window can be accessed in the software with the key combination of **CTRL + S.** This contains the application initialization setting and should rarely need to be modified. Note that the software must be restarted after saving any changes before those changes take effect.



Enable Serial Logging – This feature logs serial communication to a file in the Data folder of the application. This can be useful for troubleshooting purposes or capturing communication for reverse engineering type applications.

Require Serial Ready – When connecting to the sorter, the software expects to receive a response of "Ready" from the sorter. If it does not receive a response within 3 seconds, the sorter will be ignored and most likely the software will go into Emulation mode. For custom implementations, you can disable this requirement.

Serial Baud Rate – The default value specified in the Arduino code is 9600. If modifications to the Arduino code have been made or a different sorter device is being used, this setting can be set in the software to restore communication.

Troubleshooting

Images are black/blank when running in emulation mode.

Check your IP Tuning settings to make sure the image is within the crop area (if using manual or hybrid modes)

Sorter not detected; software goes to emulation mode.

There are several reasons for this, but the most common one is that the serial port is not available because it is in use by another application. Very typically that "other" application is the Arduino IDE. It is important to close the IDE as it can keep the serial port open and not allow the software to use it.

Another common issue is that the USB port is not connected or has a problem. You can try unplugging/replugging the USB cable or try connecting the USB cable to a different port. If you are using a USB hub, you can also try bypassing the hub and connecting the cable directly.

The Application Crashes when training starts after I press **Train Model**

This problem can occur for many different reasons, but these are the most common.

- If the CPU does not have AVX instruction support. (if you have already run a successful training previously, this is not the problem). The solution is to get a computer that supports AVX instructions.
- The processor is not x64 (64bit) architecture.
- The computer does not have an internet connection during the first training. When training a model for the first time, the software may attempt to download some of the external dependencies needed for the training. If there is no internet connection, the app may crash.
- The VS C++ redistributable was not installed. Solution is to install the redistributable from the software downloads page.
- Images have a headstamp mismatch. If you have manually renamed training images in windows explorer, you need to be sure that each classification (file prefix) also exists in the headstamp data for that model and carries the same case sensitivity. For instance, if you have a file like Fed111_23049820349823.jpg, you need to be sure your model also has a headstamp named Fed111. FED111 and fed111 are different headstamps.
- System out of memory. If your system has 8gb or less, or has other applications using resources, the system may not have enough memory to complete the operation. In this case, you should try rebooting your computer and on a fresh boot, launch the application and go directly to the training screen to run the train model operation.