Automated Target Analysis For Optimum Charge Weight Rifle Load Development

Project Proposal - EE456 Digital Image Processing

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Submitted by:

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# Summary

Within the shooting sports and hunting communities it has long be realized that handloading of ammunition is an excellent and necessary way to extract the accuracy potential of a firearm. This is especially true for benchrest shooting competitions where rifles are used at extreme ranges of 600 to 1000 yards. Competitors are scored on the accuracy and precision of multiple shots at targets at these long distances.

Handloading literally refers to assembling the components (case, bullet, powder, and primer) of a firearm cartridge to very tight tolerances and tuning various aspects of the assembly to achieve maximum accuracy. Ammunition manufacturers are not able to tune ammunition to perform in single rifle, this is why handloading is so advantageous.

The “Optimum Charge Weight” or OCW method was popularized by internet forum member Dan Newberry who laid out his methodology on his website. Charge weights tend to have the greatest effect on accuracy and they need to be tuned for a specific firearm. The reasoning is quite simple. After powder ignition, shockwaves propagate the length of the barrel and bounce back and forth causing both three dimensional deflection and bore concentricity changes at the muzzle end of the barrel. By adjusting the powder charge of a loading, the bullet velocity can be altered such that its exit from the muzzle occurs while these random changes are at a minimum. Charge weight plays a large factor, and once optimized, additional tuning by altering bullet seating depth can be performed.

OCW extends these ideas by varying charge weights to determine which adjacent charge weights have mean point of impact (POI) changing the least. For example, a starting charge weight and max powder charge weight of 25 and 26 grains are determined. This interval is broken into 6 weights (25.0, 25.2, 25.4, 25.6, 25.8, and 26.0). Multiple shots are fired at each weight at separate targets. The point of aim (POA) is consistent across all the shots, yet the average POI deviates from shot to shot and charge weight to charge weight. The mean POI for each charge weight is calculated. Next the change in mean POI from 25.0 to 25.2 grains is determined (a vector error). Next the change in POI from 25.2 to 25.4 grains, and so on. The middle of the interval with the smallest shift in POI is deemed the optimum charge (a second tier OCW can be run to gain more resolution if the charge weights are still relatively far apart). The reasoning here is simple, no two loadings are exactly the same. It is impossible to load exactly a specific charge weight, brass cases are not identical, primers have slightly different characteristics from one to the next, environmental and chamber temperatures change, and so on and so on. By choosing the middle of the range which exhibits the least change in POI we are choosing the loading that is the least susceptible to relatively large changes in chamber pressure due to the changing charge weights (and other variable as well due to their effect on pressure).

The target analysis process of OCW is manual, one uses calipers to measure target groupings to arrive at various measurements needed to compute the OCW. It can be a tedious process and like all human performed processes is subject to additional error. There are a few commercially available software packages that analyze targets, but they are generally geared toward automatic scoring systems not load development. This project will automate calculation of the optimum charge by automatically finding the “bullseye” or POA, as well as bullet holes which determine POI group statistics from an image of the final target or targets.

# Needs/Problems/Objectives

In order to calculate the OCW the following high level topics will need to be addressed

* Determine a suitable target or set of targets as standard test vehicles
  + Standard size bullseye to convert inches to number of pixels
  + Standard fiducials to align images
* Develop image registration/alignment to fiducial markings
* Develop or identify algorithms needed to segment out the target “bullseye” to determine the POA
* Develop or identify algorithms needed to segment out bullet holes to determine POI
  + Determine if algorithms are robust enough to handle overlapping holes
  + Adjust target sets according to above, perhaps one shot per target and create a composite target
* Develop scheme to determine changes in POI from group set to group set
* Develop test metrics to assess success on all of the above poitns

# Scope

Out of scope items include fully packaged release type software. This is intended to be an exercise in algorithm development not deliverable software. In addition, where possible, existing algorithms either included in MATLAB or 3rd party developed will be used. Where time permits it will be advantageous as a learning exercise to implement algorithms “in-house” but initial algorithms will likely come from MATLAB image processing library.

In scope items refer to items in Section 2. Expected time given is roughly 3-4 months at roughly 4-8 hours per week (rough estimate, homework and other exercises will affect the time given) for an overall time allotment of 24 to

# References