Estimating Muzzle to Target Distance from the Physical Characteristics of a Bullet Hole in Different Wood Substrates

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Experimental set up at the Pedico Research Institute

1. Introduction

- Determining the location of the shooter using the evidence at the scene can be a difficult task.
- The crime scene may have been tampered with, or accidently thrown out of place by first responders.
- There may be no footprints or obvious signs of the suspect
- Casings could roll away or be kicked away, bullets may not be recovered.
- However, the bullet hole itself remains a vital part of the crime scene that provides plenty of information about the shooting.
- Just the bullet hole itself can be examined for Gunshot Residue, or be extrapolated for distance and trajectory tests.
- A bullet hole at the scene of a crime can provide a plethora of information that may not be obvious at first glance.

2. Objectives

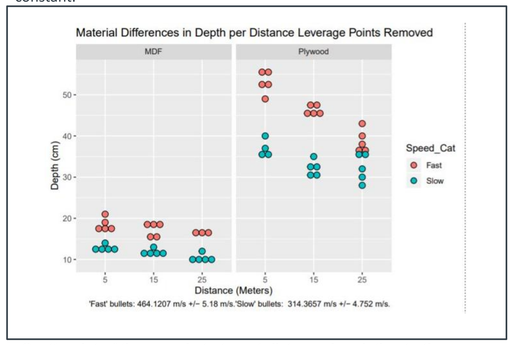
- We aim to create a method that uses the principle of kinetic energy and can relate the muzzle to target distance to bullet penetration depth.
- This method can work on wooden materials, and that different types of wood will generate different distance to depth trends.
- Other physical damage characteristics may be present on or around the bullet hole that can aid in distance determination.
- A procedure can be generated that will allow the muzzle to target distance to be approximated based on the measured bullet hole depth.
- A model can be created with statistics that can better illustrate the trends between muzzle to target distance and bullet hole depth.

3. Methods

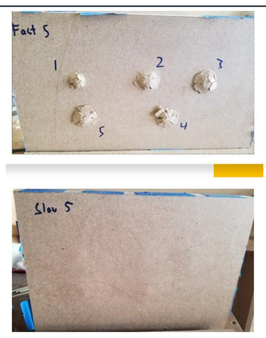
- All shots were performed on Plywood then MDF.
- Shots were all outdoors in a shooting range.
- Using the sight on the Ruger 10-22, each shot landed in the middle of the mounted target.
- The velocity of the shot was recorded with a Doopler radar system.
- The wood was thick enough so that no bullet will perforate through the target.
- Slower and faster velocity bullets were utilized for the experiment.
- The shots were also conducted at different distances.
- The depth of the bullet hole was then measured with a rod and ruler.
- Physical damage characterisitics were also observed.

4. Findings *or* Results

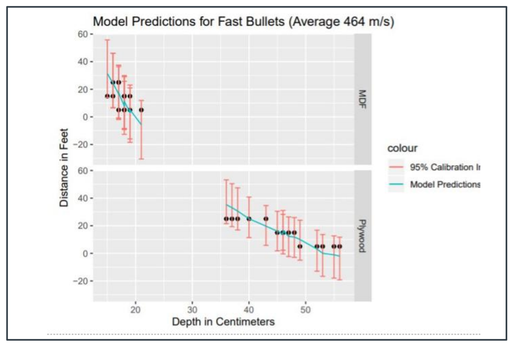
- Muzzle to target distance, bullet speed, and substrate material all affect the depth of the bullet hole.
- As muzzle to target distance increases, depth of bullet hole decreases.
- As bullet speed increases, bullet hole depth increases.
- Bullets travel farther into Plywood than MDF, and slope (magnitude of change) over distance and speed is greater in Plywood.
- For bullets shot into MDF wood, median bullet depth decreases by 4.4% for every additional 5 feet of distance the muzzle is from the target, (velocity being constant).
- For bullets shot into Plywood, median bullet depth decreases by 5.6% for every additional 5 feet of distance the muzzle is separated from the target it impacts (velocity constant).
- For bullets shot into MDF wood, median bullet depth increases by 14.2% for every additional 50 m/s of bullet speed gained, when the distance is constant.
- For bullets shot into Plywood, the median bullet depth increases by 10.6% for every additional 50 m/s of bullet speed gained, when the distance is kept constant.
- Bullets that are shot into Plywood penetrate 264% deeper than bullets shot into MDF wood, when the bullet speed and muzzle to target distance is kept constant.
- The front of all bullet holes had the same round morphology.
- For MDF wood, none of the slower bullets created any damage to the back of the substrates.
- However, all of the faster bullets created a similar segmented circular damage pattern on the back of the substrates.
- This damage was present in all MDF panels shot with faster cartridges through all three distances.
- For faster cartridges shot into Plywood at 5 feet, there existed heavy damage to the back of the substrate for all bullet, with peeling and splintering.
- Similar but less damage was seen at the 15 and 25-feet distances.
- Similar damage pattern for slower cartridges at the 5 and 15-feet distances, but no damage was observed at the 25-feet distance.



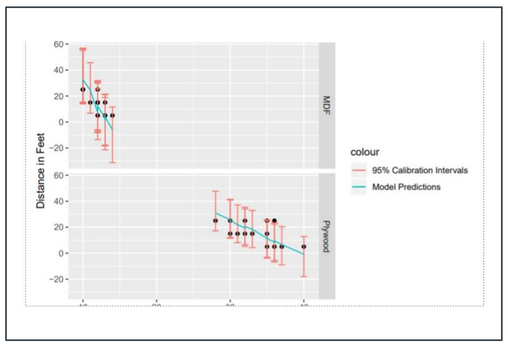
Scatterplot of the muzzle to target distance in relation to the depth of the bullet hole for both fast and slow bullets.



Physical damage characteristics for the back of the wood substrate for the fast bullets and the slow bullets.



Predictions model of muzzle to target distance and bullet hole depth for the fast bullets



Predictions model of muzzle to target distance and bullet hole depth for the slow bullets

5. Conclusions

- Results show the trend of bullet hole depth increasing as muzzle to target distance decreases, exists for the experimental set up.
- We can assume the same trend will be present for any bullet shot in the range of 5 to 25 feet.
- We can also make the same assumption for cartridges of similar caliber and type with speeds between 464 and 314 m/s.
- This trend exists for both Plywood and MDF, even though the materials react to bullet impact differently.
- The new method developed in this study overcomes these limitations by focusing only on the physical characteristics of the bullet hole.
- A trend of relating bullet hole depth to muzzle to target distances in Plywood and MDF, allowed us to generate a model that can estimate the shooter's distance.
- Unique physical damage characteristics also enable us to gauge the bullet's speed.
- It is important to note that the coefficients and model generated applies only to the cartridges, firearm, and target materials used in this experimental setup.
- New prediction models will have to be generated for different firearms and cartridges and will have their own specific coefficients.
- However, we have developed a framework that can work for other firearms and cartridges.

6. Potential for Impact

- By following the procedure with a similar formula, this model can be applied for casework.
- The bullet hole from a crime scene can be measured for depth and have the muzzle to target distance extrapolated from a predictions model.
- A key advantage to this method is that it works in tandem with other ballistic analysis methods.
- The bullet hole can be tested for GSR, or swabbed for other trace evidence such as DNA, before or after the depth measurement, without compromising the evidence.
- Bullet angle and trajectory analysis can also be performed.
- The testfires for bullet hole depth can be performed with the testfires for GSR patterns.
- All that is required at the scene is knowledge of the type of cartridge used, the material shot into, and possibly the model of the firearm.

7. Limitations

- We focused only on the 22-10 Ruger semiautomatic rifle, with hollow point cartridges, and on Plywood and MDF substrates.
- Future studies can expand with cartridges of other calibers and types, and other firearms (handguns, bursts, automatics, shotguns.)
- Other wood substrates could also be tested (sanded plywood, sheathing plywood, oriented strand board, and marker boards.)
- All our shots were made perpendicular to the target, but it can be interesting to observe bullets at non 90-degree angles.

8. Next Steps

- Improvements to our experimental design can include expanding our muzzle to target distance range and taking shots at more intervals.
- More shots per trial, and a tighter confidence interval may also improve the accuracy of the prediction model.
- A greater range of different cartridge speeds may also help us narrow down when damage occurs.

Suggested Citation

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More Information

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