Oct. 1, 2017 Gunfire Cyclic Rate & Variance Compilation

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Abstract

Gunfire from the October 1, 2017 Las Vegas Nevada shooting is measured and analyzed along with other machine guns and bump stock firings. The focus of this paper is statistical variance between shots and cyclic rate as classifiers of automatic and bump fire weapons. Measurements are based on time of arrival of direct path muzzle waves and their differentials.

Results are preliminary.

1. Introduction

Figure 1 plots variance of differentials between shots versus the average cyclic rate of fire (rounds per minute) on a per volley/burst basis.

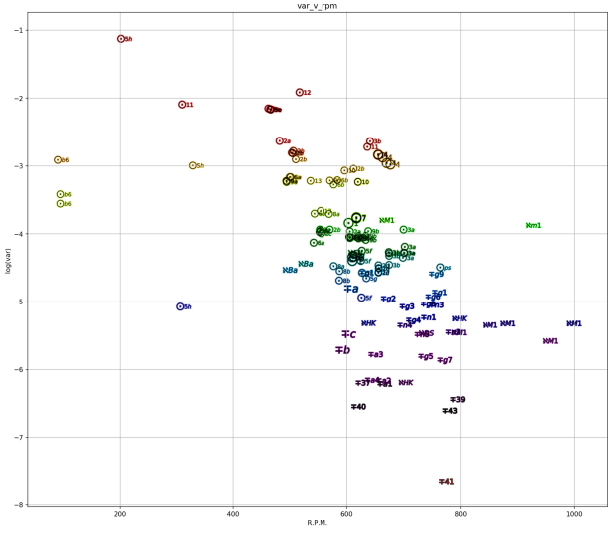

Figure 1: Variance v. R.P.M.

The y axis plots the log base 10 of the variance of the individual gunshots compared to the mean of the gunshots for any particular volley. In reading this axis the numbers are essentially the base 10 exponent of the variances. For example a value of -3 indicates a measured variance on the order of 0.001 thru 0.009. All times are in seconds.

An algorithm was applied to all values to color each item such that items with similar color could be considered as part of a grouping.

2. Included gunfire.

Included in the graph are all the volleys / bursts from the Route 91 shooting, these are marked with ʘ, machine guns from the 240/249 series ╤, and various other machine guns marked with Ϫ.

Examples of known bump stock fire are marked the same as Route 91 volleys but have unique labels.

3. Index

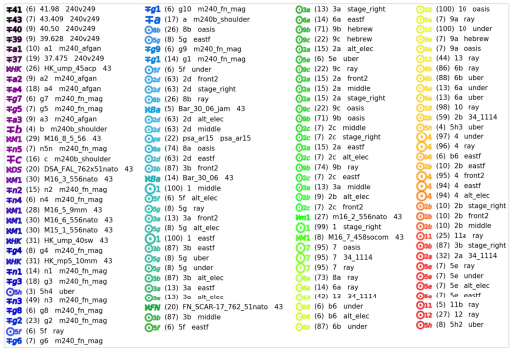

Figure 2: Index

Figure 2 is an index listing all the volleys/bursts graphed. The labels are formatted as:

<marker> <**name**> (#rounds) <**video**> <**volley**>

These labels are colored from small (darker colors) to large (red). Items with similar colors group. The colors in the index are slightly brighter because Figure 1 has a dark shadow overlay for contrast.

4. Measurement Method

Audio was extracted from every source and then spectral analysis was performed with Sonic Visualisier. Power spectrums, frequency spectrums, spectral contrast and amplitude waveforms plots were all used to examine the audio, and mark occurances of muzzle blast wave arrivals. Sonic shock waves, reflections etc. were ignored as their timing is not indicative of actual cycle rate of fire.

Individual shot times were measured to about 0.0005 seconds accuracy (½ of one milli – second).

5. Shot grouping

Once isolated, the muzzle blasts times were noted and organized into volleys and bursts. One volley may contain multiple bursts. Shots which occurred more than about 2 or 3 shots gap before or after were determined to be “new” bursts.

6. Statistical processing

After all measurements and groupings were complete, all bursts / volleys from all sources were subjected to statistical analysis via algorithms from the Python libraries scipy, numpy, pandas and librosa.

This paper exclusively presents the statistical variance portion of that analysis.

7. Observations

Many observations, great and small can made from the data in the graph. Some of the major observations:

7.1. Machine guns (r.p.m. > 600)

Volleys from known machine guns have a lower limit near 600 r.p.m.

7.2. Machine guns (variance < -5)

The variance of the time between shots, is in some measure an indication of the ability of the guns mechanical (or human) system to maintain a constant rate of fire. With a couple notable exceptions, all machines guns were able to maintain a respectable rate of fire with little variance. By example, for an r.p.m. of 600, each shot occurs at 0.100 seconds. Or $1x10^{-3}$. A variance of -5 is $1x10^{-5}$ or 0.00001 seconds. Given the variance involves power of 2 calculations the absolute deviation is on the order of 0.0032. (square root of $1x10^{-5}$). Relatively that is 3.2 / 100 or about 3%.

7.3. Machine guns, Variance independent of r.p.m.

Variance is relatively constant regardless of the rate of fire of a machine gun. That is whether the gun is firing at 600 r.p.m. or 1,000 r.p.m. they are able to maintain that rate of fire consistently.

7.4. Vegas, 250 < r.p.m. < 750

The bursts and volleys from Vegas have a large range of r.p.m. with some of the smallest being near 250 and some of the largest above 750. Large clusters are around 625.

7.5. Vegas, variance decreases with r.p.m.

The Vegas volleys variance have a small slope downward as r.p.m. increases. That is the faster the rate of fire (small gap between bullets), the better the variance or ability to maintain that rate of fire.

7.6. Vegas, -1 > variance > -5

Cyclic rate of fire for the Vegas volleys and bursts are all over the graph. Some approach the consistency of machine guns, but most do not and have relatively large variances.

8. Three Groups of Volleys

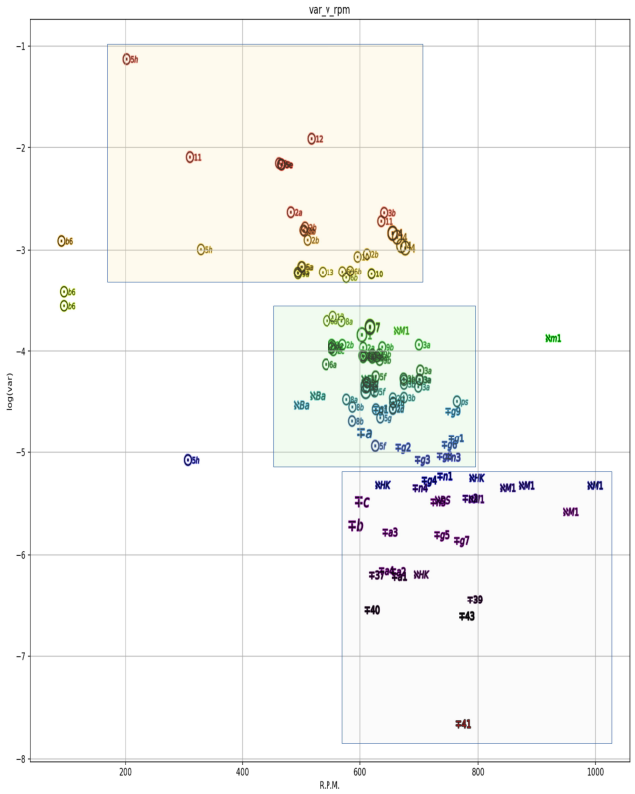

Figure 3: Volley Grouping

Based on r.p.m. and variance alone the graph can be subdivided into three groups.

8.1. Slackers (light red)

No machine guns here, these volleys are characterized by wildly varying cyclic rates and large variances.

8.2. Chameleons (light blue)

A grouping which consists of both machine guns and Vegas volleys that are hard to tell apart from r.p.m and variance alone. In this grouping as the variances grows smaller the probability of the volley being a machine gun increases.

8.3. Brutes (light purple)

Consisting entirely of guns which have a floor of 660 r.p.m. and small variances, < -5. These are automatic fire machines guns.

9. Conclusions

9.1. R.P.M. a poor classifier

For any given cyclic rate of fire, there are many different volleys and guns which are indicated making it difficult to separate each from the other on r.p.m. alone.

9.2. Variance a good indicator of mechanization

From the data, mechanized automatic weapons are mostly grouped into the brutes indicating that variance is a good predictor of mechanization.

9.3. Bump Fire can simulate automatic fire

Some of the known bump fire volleys/bursts are of the Chameleon grouping with relatively small variances, and on first blush would sound very similar to automatic fire.

9.4. Vegas Volleys likely bump fire

Vegas volleys and bursts are grouped into slackers and chameleons indicating that the probability of them being bump fire is higher than that of them being machine gun fire. More analysis is needed to determine exactly which, for those in the Chameleons.

10. Further research

10.1. Data

As indicated in the abstract this is a preliminary report. Much more data needs to be collected on both known bump fire and known machine guns for reference and inclusion into the data.

The data compiled still needs to be vetted to eliminate outliers and errors.

10.2. Questions raised

The data raises other interesting question beyond the scope of this paper. For example what is the source of the r.p.m. differences between instances of volley 4? Or how can bursts from the same volley (Vegas only) be wildly varying?

11. Video sources

11.1. Venue

1. bar5(1),
2. stage_right(2),
3. booth_se(3),
4. eastf(4),
5. middle(5),
6. front2(6),
7. alt_elec(7),
8. 34_1114(8),
9. under(9),
10. ray(10),
11. uber(11),
12. oasis(12),
13. hebrew(13)

11.2. Known Quantities

1. 240v249(14),
2. 43(15),
3. m240b_shoulder(16),
4. m240_afgan(17),
5. m240_fn_mag(18),
6. psa_ar15(removed from internet)

12. Data Repository

This paper,
Data Directory,
csv
xcel
muzzle
plots

13. References

1. Mr. Burgandy. Las Vegas Shooting - First 2 Volleys - Warning- Any Ol Barstool Aldean Route 91 Attack [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=wcYe0sb2J4M&feature=youtu.be

2. NICK VEGAS. FACEBOOK LIVE LAS VEGAS SHOOTING ROUTE 91 CONCERT -G ALLEN [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=U7Ea4y6w0_c

3. NICK VEGAS. LAS VEGAS SHOOTING VIDEO JASON ALDEAN [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=6Lf6uJEAGdE&feature=youtu.be

4. Brockton Hankins. Raw Footage Las Vegas Shooting As It Happened [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=eB4MBH9XWoo&feature=youtu.be

5. MassLive. Gunman opens fire on a concert in Las Vegas, killing more than 50 [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=V4rcXzURlAw&feature=youtu.be

6. Crystal Edivan. Vegas Route 91 Shooting front left side of venue [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=7J9HWtz3QC8&feature=youtu.be

7. Las Vegas Shooting Archive. Las Vegas Shooting - East side of venue (It's Electrical" - Alternative Perspective) [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=OJxaKuGAoCg&feature=youtu.be

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13. Las Vegas Shooting Archive. Las Vegas Shooting - Luxor Parking Lot - Volley #9 (approx. 10:12:23 PM) [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=8x1NRVYjXlY

14. Military Archive. M249 SAW & M240 Bravo Machine Gun Shooting [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=wHS78bbMdA0&feature=youtu.be

15. Washington County Machine Guns LLC. Test Fire of 43 Machine Guns - One Take, No Edits [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=bmeRROzi_4k&feature=youtu.be

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18. TFB TV. The Unstoppable M240 Bravo (FN MAG) [Internet]. [cited 2019 Jun 22]. Available from: https://www.youtube.com/watch?v=vdpdD71a8cs&feature=youtu.be