darkosu notes

RED POCKET

1 .osu file format

1.1 Hit Circles

In the .osu file format, a hit circle object might be represented like this:

119,204,270327,1,0,0:0:0:0:

The first two numbers, 119,204, represent the x and y position of the hit circle. This is in osu!pixels, where the whole hit area is scaled to 640x480, and 0x0 is in the top left corner.

The third number is the timestamp, expressed in milliseconds since the start of the map (which starts exactly when the .mp3 file starts).

The fourth number is usually either 0, 1, 3, or 7. 0 represents a hit circle, 1 a slider, 3 a spinner, and 7 an osu!mania LN. Of course, we can express these numbers as $2^n - 1$, where n ranges from 0 to 3.
The fourth number can also be 2, 4, 5, or 6. These are used to skip combo colors. 2 starts a new combo; 4, 5, and 6 skip that many combo colors (IF the object starts a new combo).

The fifth number assigns a hitsound to the object. 0 for normal, 1 for whistle, 2 for finish, 3 for clap.

The sixth number assigns parameters to the object. (The osu documentation is unclear as to what this means, I'll update this later).

The last four numbers (0:0:0:0:) represent custom hitSounds. They're not relevant to darkosu, so I'm not going to bother documenting them.

1.2 Hit Circles in Mania

x-coordinates: If the map is in n-keys, then the x-coordinate of column i is:

$$\lfloor \frac{256}{n} \cdot (2i - 1) \rfloor$$

You can try this yourself and verify that, for example, the 3rd column of a 7k map would have x-coordinate 182.

All osu!mania hit objects will have y-coordinate 192. (This also makes me suspect that the osu documentation is inaccurate and that osu!pixels are in fact scaled to 512x384).

The third number is the timestamp, as always.

For darkosu-generated files, we will leave the last arguments as 1,0,0:0:0:0:. We don't care about hitsounds or anything, that's up to the mapper.

2 Pattern Repository

2.1 Basic Terminology

A note is a single hit object.

A long note, or "LN", is a held hit object.

A jump, or a double, is hitting two notes simultaneously.

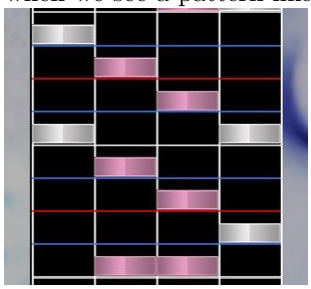
A hand, or a triple, is hitting three notes simultaneously.

A quad is hitting four notes simultaneously.

A rice map is a map consisting of exclusively or near-exclusively notes, rather than long notes.

2.2 RED POCKET notation

Very template-y rice maps will typically have a "lowest common denominator" object snapping, where almost all of the objects in the map are snapped to that level. For example, in popular map "Cyber Inductance" by IcyWorld, every single object in the main portions of the map are snapped to a 1/4 level. Thus, when we see a pattern like this:



we note this as:

[23][4][3][2][14][3][2][1]

Each pair of brackets encloses a single snap point, and each number represents a column (read from left to right). We refer to each bracket group as a "point" - for example, in the above case we would say there is a jump every 4 points.

Every 4 points is known as a "beat", which we will use to establish BPM of the map, independent of the song.

With this established, we examine some common patterns.

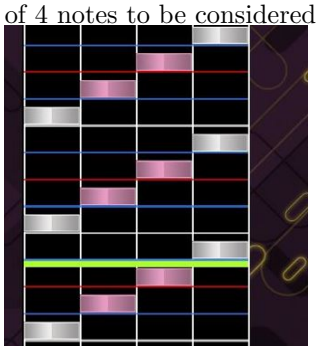
2.3 Common General Utility Patterns

We define "general utility patterns" as patterns that can appear in any kind of map, are typically short in nature, and don't define the map as a whole.

A staircase is some variant of [1][2][3][4][3][2][1], repeated any number of times.

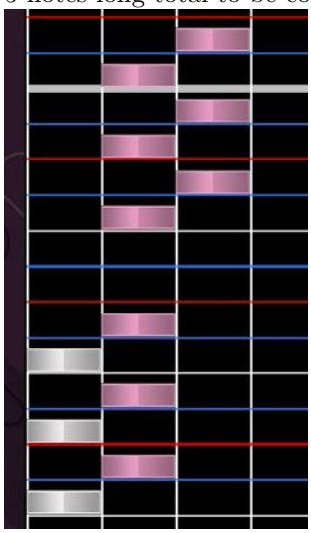
These are typically frowned upon in mapping, though common in older maps. This pattern can trivially be generalized to higher keymodes.

A roll is some variant of [1][2][3][4][1][2][3][4], or really any pattern where a) it is composed of all single notes, b) it repeats a pattern of 4 over and over, and c) the pattern of 4 goes through all 4 columns. Of course, the roll can also be generalized to higher keymodes. A roll should go through at least two "cycles" of 4 notes to be considered a roll.



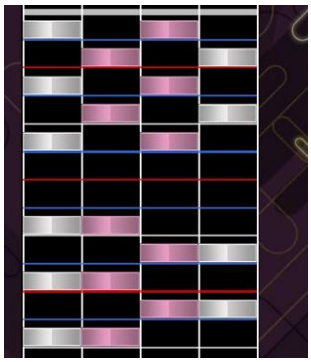
A split roll is a variant of the normal roll, where in this repeated pattern of 4, the hand which is pressing the key alternates on every key. A normal roll might have a pattern [1][2][3][4], while a split roll might have a pattern [1][3][2][4]. This is trickier to generalize to higher keymodes.

A trill is a pattern where: a) it is composed of all single notes, b) it repeats a pattern of 2 over and over, and c) the pattern of 2 is 2 distinct notes. If the 2 notes are on different hands, it is a two hand trill, and if not, it is a one hand trill. A two hand trill might be something like [2][4][2][4][2][4], while a one hand trill might be something like [1][2][1][2][1][2]. Generally the trill must be at least 5 notes long total to be considered a trill.



A jumptrill is a variant of the trill. The difference is that it is composed of all double notes rather than a single note. The "standard" jumptrill is some repetition of [12][34][12][34], and is very prevalent in ranked maps in osu!mania, as well as stamina-oriented files (more to come about that later).

A splittrill, or split trill, is a variant of the jumptrill. This time, the two jumps to be repeated are either [13][24] or [14][23], thus using both hands in every jump rather than every other jump. This pattern is also prevalent in stamina-oriented files, though less so in ranked maps.



A minijack is repeating a note on the same column twice in a row.

A longjack is repeating a note on the same column at least 5 times in a row.

2.4 Common Archetype Patterns

These patterns are map-defining in many cases, and will typically constitute the bulk of a map. I'm not going to include any more images since they're a pain, so you're going to have to read my notation. To see more information on the variants of each pattern type, see section 3.

Single streams: Any pattern $[a_1][a_2][a_3][a_4]$... comprised entirely of single notes. Pretty self explanatory.

Jumpstream: Definitely the most popular pattern out there. Some pattern $[a_1][a_2][a_3]$... where there is a jump at least every 4 points (any more than 4 usually gets classified into single stream), but no more than every 2 points (except when entering a jumptrill or split trill). Typically when speaking about jumpstream, handstream is excluded, so we establish that there are no hands or quads.

Handstream: A denser variant of jumpstream, where there is a hand at least every 8 points, but no more than every 4 points (though some parts of handstream maps may include hands every 2 points for a short period - Future Dominators and Villain Virus are examples of this). Jumps may also be included.

Jacks (in general): A jack is, loosely speaking, any pattern $[a_1][a_2]$... where a_1 and a_2 have at least one note in common. For example, [13][34] would be a jack (on column 3), while [13][24] would not. The main difference between a jack and a non-jack is that a jack forces the player to pick their hand up between notes, slowing down the maximum possible gameplay speed.
Note that stream, jumpstream, and handstream maps will typically **never** include jacks at **base snap speed**. Almost every stamina map will have a section

in the middle of jacks at 1/2 snap, but the base snap speed is 1/4.

Chordjacks: A jack map where there is a jack between almost every pair of consecutive points. It gets more nuanced than this, so read section 3.

Quadstream: The natural evolution of handstream, quadstream includes quads as well, which also forces jacks to exist. The difference between quadstream and chordjacks is that in quadstream, typically the only jacks are directly related to the notes within the quad, meaning that 2 out of 4 pairs of points in the quadstream will have jacks.

2.5 Other terminology

Burst: A temporary and drastic increase in density.

3 Detailed Archetypes and Math

Here's where the math starts coming in. Keep in mind that these will represent most of a map, not all of it, so don't freak out when my "examples" have parts in them that don't fit the criteria.

3.1 Notation

Refer to point k in sequence A as A_k. For example if we said sequence W was [12][3][4][1][23], then A_5 would be [23].

We say $n \in A_k$ if the point A_k contains column n. Going off of our example from above, $2 \in A_5$ but $4 \notin A_5$.

The "density" of a pattern is the average notes per point. Sequence A would have density 1.4 because it has 7 notes in 5 points. Denote this by $\rho(A) = 1.4$ or $\rho_A = 1.4$.

Refer to a subsequence of A by $A_{n,k}$. For example, $A_{1,3}$ would be a sequence with the points A_1, A_2, A_3.

The length of a sequence A we express as $\overline{A}$.

The magnitude, or number of notes within a point A_i, we express by $|A_i|$. For example, $|[1]| = 1$ and $|[134]| = 3$.

We extract the number within a point with $n()$. For example,

$$n([234]) = 234$$

We endow each point with a 4-bit binary representation. We let:

$$f([1234]) = 1111_4$$

$$f([2]) = 0100_4$$

The rest should follow trivially.

We define addition as set union. $[12] + [23] = [123]$.
Multiplication is intersection. $[12] \cdot [23] = [2]$
Subtraction is subtraction. $[12] - [23] = [1]$

3.2 Formal Definitions of Section 2

All patterns are named "A" unless specified otherwise.

Let $\mathbb{N}$ represent the set of indices of the sequence (too lazy to write it out).

Staircase:

$$\exists k \in \mathbb{N} : 0 \leq k \leq 5 : \forall n \in \mathbb{N} : A_{k+6n,k+6n+5} = [1][2][3][4][3][2]$$

$$\overline{A} \geq 7$$

Roll (Base):

$$\forall i \in \mathbb{N} : |A_i| = 1$$

$$\forall x, y \in \mathbb{N} : A_{x,x+3} = A_{x+4y,x+4y+3}$$

$$\forall x \in \mathbb{N}, \forall k \in \{1, 2, 3, 4\} : [k] \in A_{x,x+3}$$

$$\overline{A} \geq 8$$

Roll (Inward):

$$\exists k \in \mathbb{N} : 0 \leq k \leq 3 : \forall n \in \mathbb{N} : A_{k+4n,k+4n+3} = [1][2][4][3]$$

Roll (Outwards):

$$\exists k \in \mathbb{N} : 0 \leq k \leq 3 : \forall n \in \mathbb{N} : A_{k+4n,k+4n+3} = [2][1][3][4]$$

Roll (Split): (assuming normal roll criteria satisfied)

$$\forall x \in \mathbb{N} : 3 < n(A_x) + n(A_{x+1}) < 7$$

Trill (All):

$$\forall i \in \mathbb{N} : |A_i| = 1$$

$$\forall x, y \in \mathbb{N} : A_{x,x+1} = A_{x+2y,x+2y+1}$$

$$\forall x \in \mathbb{N} : A_x \neq A_{x+1}$$

$$\overline{A} \geq 5$$

Trill (One hand):

$$\forall x \in \mathbb{N} : n(A_x) + n(A_{x+1}) = 3 \vee n(A_x) + n(A_{x+1}) = 7$$

Trill (two hand):

$$\forall x \in \mathbb{N} : 3 < n(A_x) + n(A_{x+1}) < 7$$

Jumptrill (All):

$$\forall i \in \mathbb{N} : |A_i| = 2$$

$$\forall x, y \in \mathbb{N} : A_{x,x+1} = A_{x+2y,x+2y+1}$$

$$\forall x \in \mathbb{N} : A_x \cdot A_{x+1} = \emptyset$$

$$\overline{A} \geq 5$$

Jumptrill (Standard):

$$\exists i \in \mathbb{N} : A_i = [12]$$

Split trill:

$$\nexists i \in \mathbb{N} : A_i = [12]$$

Jack:

$$\exists i \in \mathbb{N} : |A_i \cdot A_{i+1}| > 0$$

Minijack:

$$\forall i \in \mathbb{N}, i > 1 : |A_i| = 1$$

$$\overline{A} = 2 \vee 3$$

$$\exists k \in \{1, 2, 3, 4\} \, \forall i \in \mathbb{N} : k \in A_i$$

Longjack:

$$\overline{A} \geq 5$$

$$\rho(A) < 1.5$$

$$\exists k \in \{1, 2, 3, 4\} \, \forall i \in \mathbb{N} : k \in A_i$$

Anchor (Stream): (7 instead of 5 if $\rho \geq \frac{7}{4}$ since it's forced)

$$\exists k \in \{1, 2, 3, 4\} \; \exists j \in \mathbb{N} \; \exists n \geq 5 : \; k \in \prod_{i=0}^{n} A_{j+2i} \wedge k \notin \sum_{i=0}^{n-1} A_{j+2i+1}$$

Anchor (Jacks):

$$\exists k \in \{1, 2, 3, 4\} \; \exists j \in \mathbb{N} \; \exists n \geq 5 : \; k \in \prod_{i=0}^{n} A_{j+i}$$

Double Anchor (Stream):

$$\exists (a, b), (c, d) \in \{(1, 2), (3, 4)\} \; \exists j \in \mathbb{N} \; \exists n \geq 5 : (a, b) \neq (c, d)$$

$$a, b \in \prod_{i=0}^{n} A_{j+2i} \wedge a, b \notin \sum_{i=0}^{n-1} A_{j+2i+1}$$

$$c, d \notin \prod_{i=0}^{n} A_{j+2i+1}$$

3.3 Additional Notation

We define $\gamma(A)$ as the jack density of a sequence. This is the number of jacks divided by $\overline{A} - 1$. A sequence of [1234][123][234][124] would have $\gamma(A) = \frac{7}{3}$. Recall that we define a jack by $|A_i \cdot A_{i+1}| = \#$ of jacks between points A_i and A_{i+1}.

In the absence of any jacks (which would be stream maps), we define $\phi(A)$ as the mean anchor length. To clarify this, any note played exactly 2 snaps after the previous note on the same column extends the length of an anchor by 1. If a note is not played within 2 snaps on the same column, the anchor breaks

and a new anchor is started.

Define $\phi(A, n)$ as the proportion of anchors with length greater than or equal to n. Again, applicable if $\gamma(A) = 0$. If chordjack, consider anchors to be notes played directly in succession rather than with 1 in between.

Define $\gamma_t(A)$ as the jack frequency of a sequence. This is the proportion of consecutive pairs of points that contain a jack.

If the sequence $|A_1|, |A_2|, ...$ contains a finite repeating subsequence $a_1, a_2, ..., a_n$, we say the sequence admits a "density cycle" and write it $a_1 - a_2 - ... - a_n$. If that was unclear, Quadraphinix has density cycle 3-1-2-1. Denote the density cycle of A with $\mu(A)$.

Denote by $\omega(A)$ the proportion of points with magnitude 0.

Denote by $\chi(A)$ the "elective trill frequency". The proportion of notes that are the 3rd or later note in a single trill, that could have broken the trill while preserving the density cycle and jack density of the sequence. (kinda convoluted but I need to justify shoegazer).

Denote by $\tau(A)$ the single trill frequency. The value of $\tau(A)$ is the proportion of notes that are part of a single trill of length 4 or greater.

Denote by $\delta(A)$ the jumptrill frequency. The value of $\delta(A)$ is the proportion of notes that are part of a jumptrill with length 5 or greater.

Denote by $\epsilon(A)$ the jumptrill to split trill frequency. The value of $\epsilon(A)$ is the ratio of the number of notes part of a jumptrill with length 5 or greater to the number of notes part of a splittrill with length 5 or greater.

We calculate the balancing of left and right hand by examining each subset of 24 points for stream and 12 points for jack. Denote by $\mu(A)$ the mean hand placement (0 for left, 1 for right), and $\sigma(A)$ the standard deviation of the means of each subset of 24/12.

3.4 Red Pocket Format (R)

In R, RED POCKET format is written in the form of a 2-column data frame. The first column, titled 'c', contains the column of each hit object, while the second column, titled 't', contains which point each hit object corresponds to. Points begin at 0.

3.5 Archetype Definitions

Single Stream:

$$\mu(A) = 1$$
$$\gamma(A) = 0$$

Jumpstream:

$$\forall i \in \mathbb{N} : 0 < |A_i| < 3$$
$$\exists i, j \in \mathbb{N} : |A_i| = 1,\ |A_j| = 2$$
$$\gamma(A) = 0$$

Speed (Jumpstream subset):

$$\rho(A) \leq \frac{7}{6}$$

Handstream:

$$\forall i \in \mathbb{N} : 0 < |A_i| < 4$$
$$\exists i, j, k \in \mathbb{N} : |A_i| = 1,\ |A_j| = 2,\ |A_k| = 3$$
$$\gamma(A) = 0$$

Chordjack:

$$\forall i \in \mathbb{N} : 0 < |A_i|$$
$$2 \leq \rho(A) \leq \frac{7}{2}$$
$$\forall i \in \mathbb{N} : |A_i \cdot A_{i+1}| > 0$$

Quadstream:

$$\forall i \in \mathbb{N} : 0 < |A_i|$$
$$4 \in \mu(A)$$
$$\gamma(A) < 1$$

3.6 Single stream / "Speed"

We typically refer to single stream maps as speed maps. This encompasses any purely single stream map or any jumpstream map where the density is at most $\frac{7}{6}$.

3.6.1 Korea Streams

Known as "Korea Streams" or "Korea Dumps", these type of stream maps are made by mappers such as ATTang, [Crz]Rachel, and snoverpk. Perhaps the easiest example to understand is the map "Mario Paint [D-ANOTHER]". The map archetype relies on 2 principles:

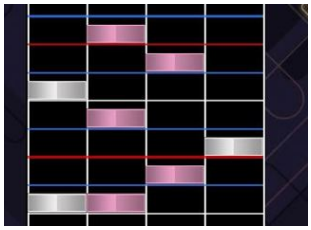
1. Do not have a note played twice within 2 points.
2. Do not repeat any sequences of length between 6 and 24.

To clarify principle 1, we say that a sequence [1][2][3][1] would be acceptable, while [1][3][1] would not. These two principles combined make for incredibly "spaced" streams, and typically allow for the highest possible BPM to be played. Principle 2 is simply so that mappers do not necessarily Ctrl+C Ctrl+V the entire map (though they might).

Of course, these two principles alone do not make a good Korea stream map. We need to consider two additional principles:

3. Balance the left hand and right hand.
4. "Switch" hands more often than not when given the choice.

Principle 3 is a good principle for almost every map, unless there is justification not to balance the hands within the music. Principle 4 might be confusing, however. Consider the following snippet of a speed map:



According to principle 1, the next point can either be [1] or [4]. Thus we consult principle 4 for wisdom, which suggests that we should switch hands more often than not. Here the previous point was [2], and [4] would switch hands while [1] wouldn't. Thus we should pick [4].

More formally, we state the criteria:

$$\forall i \in \mathbb{N} : \; k \in \{1,2,3,4\} \wedge k \in A_i \implies k \notin A_{i+1} \wedge k \notin A_{i+2}$$

$$\forall i \in \mathbb{N} : \; |A_i| < 3$$

$$\forall i \in \mathbb{N} : \; |A_i| = 2 \implies |A_{i+1}| = |A_{i+2}| = |A_{i+3}| = |A_{i+4}| = |A_{i+5}| = 1$$

3.6.2 Index Streams

Index streams are purely single stream maps (no jumps, no jacks) intended to be played on the arrow keys with the two index fingers. Because of this, they adhere to some mapping rules to ensure playability.

1. Force the player to "start" with one hand or the other.
2. Column 2 is down, column 3 is up.

Principle 1 essentially tells you to make your first note either [1] or [4]; this way you know that the player will start with either his left hand or his right hand, rather than dealing with the ambiguity of a [2] or [3] start.

For this section I will denote $[n]_R$ as playing $[n]$ with the right hand and $[n]_L$ as playing $[n]$ with the left hand.

The only forbidden note placements are $[1]_R$ and $[4]_L$. All other note placements are fair game.

More formally,

$$\forall i \in \mathbb{N} : |A_i| = 1$$

$$\forall i, j \in \mathbb{N} : A_i = A_j = [1] \implies A_i - A_j \equiv 0 \mod 2$$

$$\forall i, j \in \mathbb{N} : A_i = A_j = [4] \implies A_i - A_j \equiv 0 \mod 2$$

3.6.3 Evening 1/6 Roll Speed

3.7 Jumpstream and Handstream

The next few jumpstream / handstream (JS / HS for short) map archetypes are all similar, just with slight differences. Ordered in terms of relative difficulty.

3.7.1 Light JS

Examples: Brute Force, Lazorbeamz

Characteristics: $\rho(A) < 1.5$

3.7.2 wh1teh

Examples: Yuru Fuwa Jukai Girl, most NikoSek maps

3.7.3 Standard NB4

Examples: Cyber Inductance, Japanese Transformation, Lolit Speed

Characteristics: $\mu(A)$ = 2-1-2-1. There tends to be a jumptrill every 16 measures.

3.7.4 Standard NB4 Mixed

Examples: Burst Linker, GHOST [Lynessa], Image Material, M-A

Characteristics: $\mu(A)$ = 2-1-2-1 and 3-1-1-1

3.7.5 Shoegazer

Examples: Over the Fullereneshift [Second Impact], Fake Promise, Time to Say Goodbye

Characteristics: High prevalence of one hand trills, two hand trills

3.7.6 Pacific Girls

Examples: Pacific Girls (IcyWorld)

Characteristics: $\mu(A)$ = 2-1-1-2-2-1-2-2

3.7.7 JSOF

Examples: We Luv Lama (ending), Night of Core, Takecore of Yourself

Characteristics: Jumpstream with high prevalence of odd-numbered split-trills and jumptrills. Density ≥ 1.625.

3.7.8 Evening

Examples: Shinbatsu o Tadori, K.Y.A.F.A. [Unstoppable Domination], Soldiers of the Stamina

Characteristics: Handstream with density < 1.7.

3.7.9 Quadraphinix HS

Examples: Quadraphinix, Klassiker Einheit, The Hypocrisy (Evening)

Characteristics: 3-1-2-1 handstream avoiding double anchors.

3.7.10 Future Dominators

Examples: Future Dominators

Characteristics: 3-1-2-1 handstream with double anchors.

3.7.11 Lynessa HS

Examples: ANOMALY, Villain Virus, Freedom Dive

Characteristics: 3-1-2-1 handstream with high prevalence of split-trills and jumptrills.

3.8 Chordjack

Chordjack maps have a few main characteristics to distinguish themselves from other chordjack maps. We have:

1. Pure note density
2. Jack density
3. Anchors
4. Single-hand jack density

While it is widely believed that pure note density is the main factor behind the difficulty of chordjacks, I believe that it is less important than the other 3 factors.

3.9 Pure note density

Every chordjack map that could be remotely considered chordjack has $\rho \geq 2$. Most chordjack maps are closer to the value of $\frac{11}{4}$, though some really dense maps might approach $\frac{7}{2}$.

3.9.1 Jack density

Every map has $\gamma_t \geq \frac{1}{2}$, though usually it is closer to 1.

We can calculate the minimum and maximum jack densities from ρ. Trivially we know $\gamma \leq \rho$ since you can have at most one jack per note. We also know that $\rho > 2 \implies \gamma > 0$ by pigeonhole principle. Then we have, for $\rho \geq 2$,

$$2\rho - 4 \leq \gamma \leq \rho$$

3.9.2 Anchors

In a jack map, anchors are consecutive jacks on the same column. Observe that a jack density of greater than $\frac{n-2}{n}$ forces anchors to exist of length at least n. All other things equal, it is widely accepted that anchors increase difficulty.

3.9.3 Single-hand jack density

This is more of an extension of anchors, though with more nuance; also, this is the reason why **we cannot claim that every note adds a non-negative amount of difficulty to the map**.

Consider the patterns:

$$A = [12][12][12][12][12]$$

$$B = [12][1][12][2][12]$$

$\rho(A) > \rho(B)$, $\gamma(A) > \gamma(B)$, $\gamma_t(A) > \gamma_t(B)$, but everyone would agree B is harder than A.

3.10 Tech

4 Osu Replay File Format

osrparse on github seems to not be working properly, so I'm coding my own. ASCII analysis and reading osrparse documentation is the way to go. It seems like the .osr file is "packed binary data", so:

4.1 Considerations (please read this)

Python parses in "reverse". If a 4 byte integer was written as 32 12 eb 9b, Python would read it as having value $9beb1232_{16}$.

Peppy uses 0b and 00 as "throwaway characters". 0b indicates the boundaries of a string, so a string should have 0b at the beginning and the end.

4.2 Issues with osrparse

osrparse seems to think that judgment counts are signed shorts, when in fact they are unsigned shorts. Just take for example Myuka's play on Parallax II, where he gets 40037 300g's. The associated hex value for his judgments is 0x9c65, equal to 40037. However, using osrparse would have you believe that he achieves -25499 300g's. Thus instead of using "h" we use "H" as the string format when considering shorts.

4.3 Format

.osr contains the following data in hex form and in this order:

1. Mode, a 1-byte signed char. Should literally represent mode number.
2. Game version, 4-byte int. Is in YYYYMMDD format (e.g. 20200427).
3. Throwaway character, then space (either 00 20 or 0b 20)
4. Beatmap hash, literal string.
5. Two throwaway characters
6. Username, literal string.
7. Throwaway character, space
8. Replay hash, literal string
9. 300 count, 2-byte unsigned short
10. 100 count, 2-byte unsigned short
11. 50 count, 2-byte unsigned short
12. 320 count, 2-byte unsigned short

13. 200 count, 2-byte unsigned short
14. Miss count, 2-byte unsigned short
15. Score, 4-byte signed int.
16. Max combo, 2-byte unsigned short
17. "Perfect", a boolean (01 = true, 00 = false)
18. Mods, 4-byte int.
19. 0b
20. Life bar, a pipe (7c) delimited string. Ends after last comma. If life bar doesn't change ever, will be 00.
21. Timestamp, a 8-byte long long (in 10^{-4} seconds since 1-1-0001)
22. Replay length, 4-byte int. Represents the number of bytes in the replay data.
23. LZMA-compressed replay data and the RNG seed.
24. The replay ID, a 8-byte long long.

4.4 Mods

Will update this later.

4.5 Life Bar

It seems to be a series of timestamps and life bar levels. Will update later, since it's not very relevant and I don't care about it.

4.6 Replay Data

Comma and pipe delimited. Might look something like

$$0|12.72727|0,17|0|12.72727|0,18|0|12.72727|0,16|0|12.72727|0,15|0|12.72727$$

The commas separate hit events, and the pipes create sub-arrays within hit events.

The first number in each group is the "time delta", which is the time since the last event (not sure how this works?)

The second number in each group is the "X coordinate". Evening claims they're written in reverse RP 4-bit format (1, 2, 4, 8 = keys 1, 2, 3, 4, combinations are adding them). They're literally all 0 in my replay file. However, this is true

for Myuka's replay file (could my file be corrupted? who knows)

The third number in each group is the "Y coordinate". They're all 12.72727 for whatever reason, which is roughly equal to $\frac{140}{11}$.

The fourth number is also all 0. Represents "KeysPressed".

The last characters should be a pipe, followed by the RNG seed as an int, then a comma.

4.7 Limitations

Obviously with a limited amount of bytes comes a limited amount of values. Thus we observe that if a beatmap has at least $16^4 = 65536$ objects and the player gets a 1 million on it (or if a single judgment is greater than 65536), there is a chance that .osr will shit its pants when trying to figure out how many judgments they have. Behavior not tested.

5 Probability and Simplification

Not really simplified, more "streamlined". We aim to prove in this section that archetype-driven skillsets like the ones we see in Etterna don't really exist, and that one person's skillsets are far more basic than that.