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A PRELIMINARY REVIEW OF MULTISCALE FRET AS INNOVATION OF ERGONOMIC GUITAR

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ABSTRACT

The development of multiscale fret as innovation of ergonomic guitar concept aims to make this innovation applied more by guitar luthiers in designing a guitar signature that is modern and ergonomic. This concept has its own advantages, not only producing specific and organic tones, but also has benefits that can minimize the risk of repetitive strain injuries that are often experienced by guitar players. Therefore, multiscale fret has begun to be widely developed and has become one of the alternative innovations that can be applied by guitar luthiers that still adopt conventional fret concept. This paper conducts an preliminary information of the innovation of multiscale fret in a guitar that is associated with aspects of ergonomic comfort. In further research, this is expected to be a reference to understand the basic of multiscale fret and a stepping stone in conducting more systematic review regarding the effectiveness of the performance of human-centered musical instruments.

Keywords: Ergonomic guitar, comfort, multiscale fret, performance

INTRODUCTION

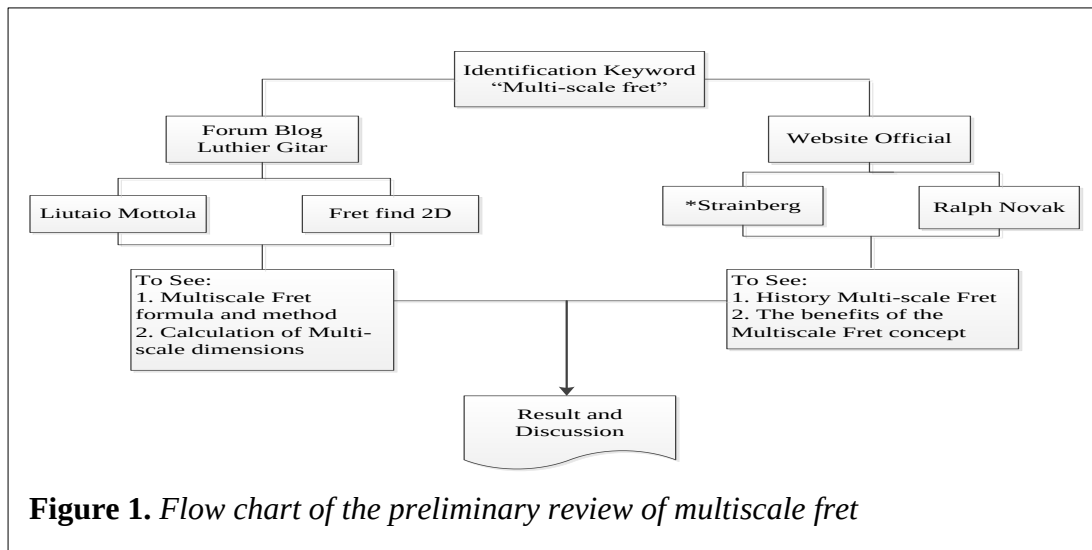
Multiscale or fanned fret Novak (2004) is a fretboard with several long scales containing frets that are not perpendicular to a geometric pattern with a straight center line or neutral point of the fret on the fretboard. In 1989 Ralph Novak (2004), a guitar luthier and a blues musician, registered patent of a new type of fret called fanned fret. Novak still holds the trademark of multiscale or fanned fret to date and has become a benchmark for other luthiers to develop it, where it is known that the low tones produced by heavier measuring strings. In general, the tones and accuracy of the intonation are improved, so that when trying to

build an extended range guitar, it often refers to guitar that have more than 6 strings although the 6 strings guitar has a longer scale and lower scale as a result.

The Novak's research and design philosophy Novak (2004) was about how to improve music performance, where aesthetics and gimmicks have a high selling value on the market, while musicians nowadays are smart enough to recognize the benefits of instruments that go beyond material and construction quality as a standard and are able to embrace concept of sophisticated design and eliminate limitations and allow wider freedom of musical expression. However, the production of guitars from the manufacturer still must pay attention to the aspects of efficiency and effectiveness in order to increase profit (Sulistiono, Ishartomo, Raharjo and Rosyidi, 2019).

METHOD

This paper aims to provide preliminary information related to the study of multiscale fret. The process of collecting data was done by using secondary data obtained online from the guitar luthiers blog forum and official websites which have become trademark in the use of the multiscale concept. and please note that looking for the latest references about an electric guitar in more detail on a luthier forum such as trusted blogs and websites. so, it is like that to find references regarding electric guitars. The flowchart of the study shows in Figure 2 below.



The guitar luthiers blog forum that serve as a reference in determining valid multiscale dimension calculation formulas are Liutaio Mottola (2018) and FretFind2D (2012). Liutaio Mottola has been classified several fret position calculation methods, both single fret and multiple fret. Whereas FretFind2D provided more complex calculations and details in determining multiscale fret dimensions so that it is able to calculate more fret and strings. This preliminary information will be very essential as a basis for systematic research on fret innovation with the ergonomic comfort in playing a guitar with an emphasis on the human-centered musical instruments design as the main focus. In this paper, it explains that the criteria for finding references are more to blog posts from a guitar luthier or guitar craftsman who understands all about electric guitars. A good luthier forum will be seen from his work on making an electric guitar on a blog or website.

RESULT AND DISCUSSION

Single Fret System Or Conventional Fret

Conventional fret calculation

Calculating fret position requires a basic mathematical science. However, those who are not interested in mathematics can use web or mobile applications that are made to calculate fret lengths with more accurate constants [3]. The manual method for calculating conventional fret is done with the following formula:

$$SL/F = F1 \quad (1)$$

$$(SL - F1) / F = F2 \quad (2)$$

From equation (1) and (2) above, it can be explained that SL is the scale length, which is the distance from nut to bridge, while F is the distance from nut to fret. The $F1$, $F2$ are the fret 1 and fret 2 respectively, so that we can use the same formula to find the next fret. Table 1 below is an example of calculating the fret dimensions on an electric guitar named TS-8 [5], then implemented on the fretboard design, as shown in Figure 3 below.

Table 1.

Fret dimensions of TS-8 electric guitar (Sulistiono, Suhardi & Susmartini, 2020)

Tab	Nut	Next fret	Fret interval	Tab	Nut	Next fret	Fret interval
1	0	3,6352	3,6352	16	37,5375	39,066	1,5284
2	3,6352	7,06648	3,4312	17	39,066	40,5086	1,4426
3	7,0664	10,3051	3,2386	18	40,5086	41,8703	1,3616
4	10,3051	13,3620	3,0568	19	41,8703	43,1556	1,2852
5	13,3620	16,2473	2,8853	20	43,1556	44,3687	1,2131
6	16,2473	18,9706	2,7233	21	44,3687	45,5137	1,145
7	18,9706	21,5412	2,5705	22	45,5137	46,5945	1,0807
8	21,5411	23,9674	2,4262	23	46,5945	47,6146	1,0201
9	23,9674	26,2575	2,2900	24	47,6146	48,5774	0,9628
10	26,2575	28,4190	2,1615	25	48,5774	49,4863	0,9088
11	28,4190	30,4592	2,0402	26	49,4863	50,3441	0,8578
12	30,4592	32,3849	1,9257	27	50,3441	51,1537	0,8096
13	32,3849	34,2026	1,8176	28	51,1537	51,918	0,7642
14	34,2026	35,9182	1,7156	29	51,918	52,6393	0,7213
15	35,9182	37,5375	1,6193	30	52,6393	53,3201	0,6808



Figure 2. *Conventional fretboard 30 fret*

The disadvantages of conventional fret.

In general, conventional fret or commonly called as single fret has become a benchmark in making guitar lutherie. However, many luthiers and also musicians found difficulties to explore more complex tones. For example, when you want to determine the best scale to get a high E string tone with a length scale of 25", but if it adjusted to the D tone, you will hear a floppy or muddy sound on that scale. If the length scale changed to 26", the D tone will become even bigger, so the high E tone will be pierced (Strandberg, 2020).

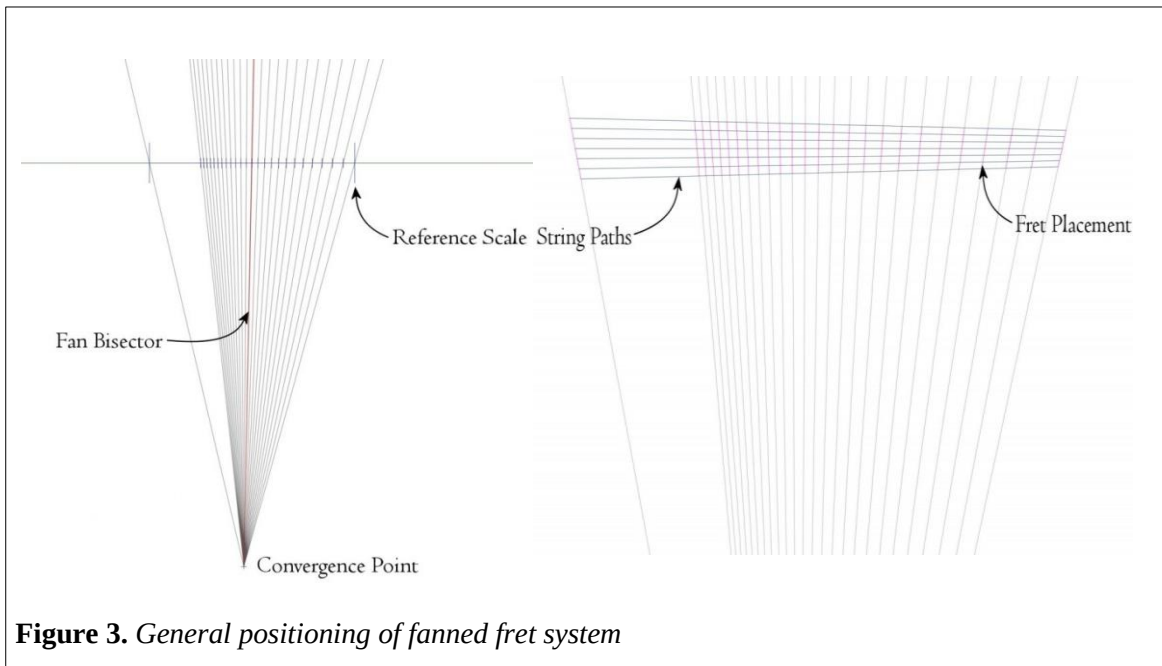
Multiple Scale System Or Fanned Fret

The emergence of multiple scale fret concept.

The concept of instrument arranged by using different length scales on each string is not a something new. The clearest and most recognizable example is the string scheme on the grand piano, as well as on other musical instruments such as harpa, lyres, psalterys, hammered dulcimers, etc. This concept is also applied to the guitar nowadays. The basis of multiple scale fret or also known as fanned fret system is obtained specifically to choose a different scale for each string that is very suitable for the needs of musicians who often improvise in playing a chord with varying tones. All the required criteria can be fulfilled without sacrificing one of the strings so that we can get great mellow treble tones with the length scale of 25" and strong clear bass tones with the length scale of 26" (Lewis, 2015).

The Novax® multiple scale or fanned fret system.

Multiscale is a simple method that can produce compound scales on multiple strings, but has one important disadvantage that the system only really functions if all the strings are parallel to the frequency scale. This system considers points of convergence to one side by paying attention to the center of the frequency scale (Maltby, 2012), as shown in the following Figure 4.



On the reference scale that is shifted to the outer string path, the placement of the fret system will leave the bass string progressively flatter on the fingerboard and the treble string will be sharper, so that 24 frets will become semitone sharp. Mapping the second root of 2 frets location along each string path in Figure 5 shows that the use of fret placement from a single converging point in space is the worst, while differences in the implementation of the fanned fret system on a real system can be relied upon to produce scale components that will later look simpler, authentic, and has its own trademark.

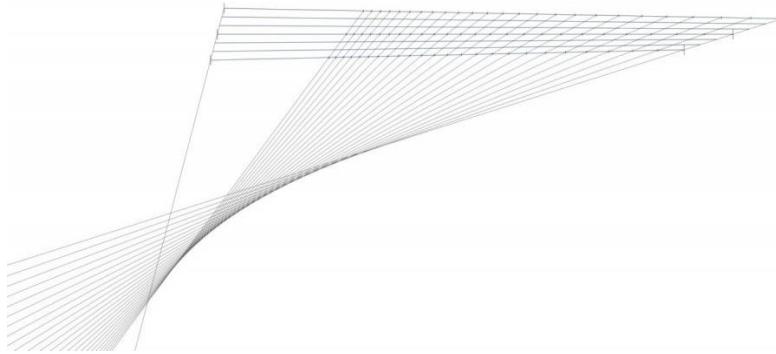


Figure 4. *Placement of the second root of 2 frets location invalidates the idea of converging point*

The next discussion is the placement of double scale interpolated frets, in which a better way of producing fret placement works in a multiscale system for string dimensions. Referring back to the previous Figure 4 which shows that dividing the two outer string lines and combining the points of each intermediate string placement are in perfect alignment.

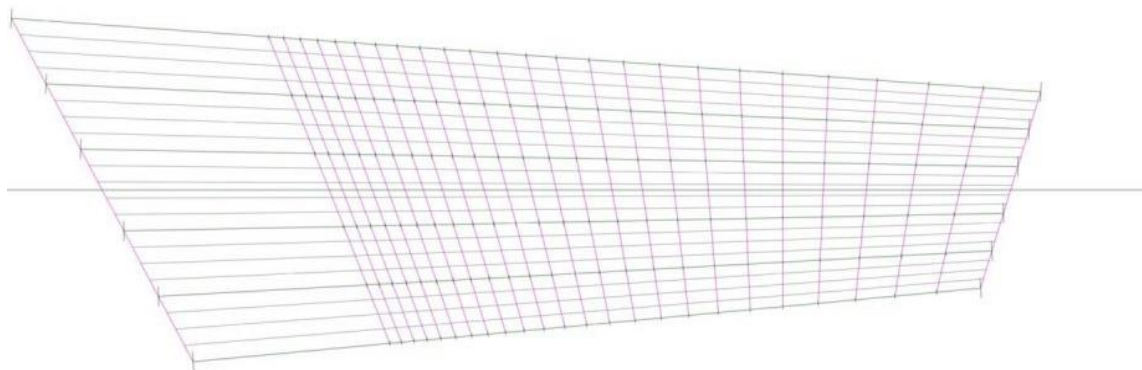


Figure 5. *A theoretical 22 strings instrument, from the second root of the scale placed above the outer string*

More or less, this system is the basis behind how FretFind2D [4] works when planning various scales, and produces good quality instruments that are well-grounded. It would be better to choose to design the instrument by hand in a Computer-Aided Device (CAD). It is sufficient to test the multiscale dimension layout by stretching the scale template above each string path as in Figure 6. If the points between the string path and the interpolation fret coincide, then the design proves to be good.

Multiple scale fret calculation.

In determining fret dimensions accurately, guitar luthiers can use FretFind2D web application according to the length scale needs to be used. Table 2 and Table 3 are the calculation example of multiple 6 strings guitar dimensions using FretFind2D [4], then implemented to fretboard design in Figure 7 (neck) and Figure 8 (strings).

Table 2.

Calculation of multiple 6 strings guitar dimensions (neck)

	Endpoints	Length	Angle
Nut	((1.9375,1.70472) : (0.375,0))	2.3124587052500787	-132.50758008123555
Edge 1	((1.9375,1.70472) : (2.3125,26.53344))	24.831552961542876	89.13470034979859
Midline	((1.15625,0.85236) : (1.15625,27.3497))	26.497338034224413	90
Edge 2	((0.375,0) : (0,28.16595))	28.16845110145694	90.76278784189786
Bridge	((2.3125,26.53344) : (0,28.16595))	2.830683270304624	144.77969527577443

Table 3

Calculation of multiple 6 strings guitar dimensions (strings)

	Endpoints	Length	Angle
String 1	((1.84375,1.60243) : (2.21875,26.59962))	25	89.14053107516418
String 2	((1.56875,1.3024) : (1.79375,26.89965))	25.59823647550689	89.49638263538131
String 3	((1.29375,1.00237) : (1.36875,27.19968))	26.197415253874905	89.83596895755318
String 4	((1.01875,0.70234) : (0.94375,27.49971))	26.797473126844583	90.16035799544309
String 5	((0.74375,0.40231):(0.51875, 27.79974))	27.3983523346929	90.47052812292917

	((0.46875,0.10228):(0.09375,	28	90.76737713163651
String 6	28.09977))		

From the inputs that used to determine the fret dimensions for the 6 strings guitar so that we get the results from the Table 2 and Table 3 above, knowing that the scale used are:

- First string scale length = 25"
- Last string scale length = 28"
- Perpendicular fret distance = 0.5
- String width at the nut = 1.375"
- String width at the bridge = 2.125"
- Fretboard overhang = 0.09375
- Number fret = 24
- Number string = 6

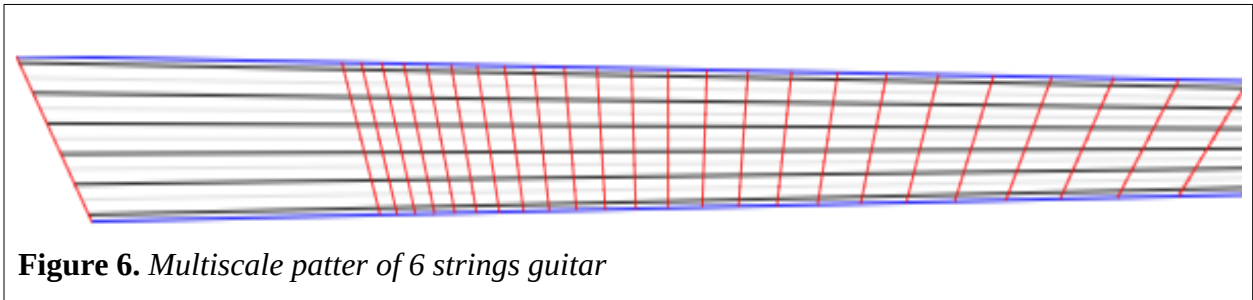


Figure 6. *Multiscale patter of 6 strings guitar*



Figure 7. *The result of fretboard multiscale 6 strings guitar*

The role of multiple scale fret on ergonomic guitar.

Most people will definitely ask whether the guitar that uses multiscale concept is really comfortable to play. Actually the guitar that uses this concept is more ergonomic to play, compared to conventional fret. You can place your palm hand and spread your fingers as wide as possible. From the differences of the following Figure 9 and Figure 10 below, you can see how the fingers when playing chords can easily reach the entire set of tones on the fretboard comfortably (Tom, 2012).



Figure 8. *Chord position on multiscale fret and Chord position on single fret*

Compared to single fret system, multiple fret which implemented in guitar fingerboard is believed to only require a little adaptation in tinkering with the wrist. Some important points have to consider when determining and designing multiscale fingerboard fret to avoid damaging the ergonomic side of comfortness. The accuracy of fret dimension is a must in order to produce perfect tones. Several applications are available to help calculating the length scale of each guitar fret and have been widely used by guitar luthiers and musicians to customize their ergonomic guitars.

Benefits of the multiscale fret innovation in ergonomic guitar.

The multiscale fret innovation has many benefits for musicians. Not only about the quality of the tone, but also the comfort of playing musical instruments that can reduce the fatigue effects in the wrist and fingers so it can minimize repetitive strain injuries. The summary of the benefits of using multiscale fret is as follows:

- Instrument with multiscale system that has fret pattern arranged geometrically or flutter, capable of producing different scale lengths for each string.
- Stability on the wrist, which occurs at the neutral point of the fretboard, where the fret is mostly perpendicular to the strings can reduce the burden when playing chords.
- The scale length and neutral point need to be chosen not only for the tone, but also for its ergonomic comfort.
- Allows all tuning to be played and produces good tones from the lowest or the highest intonations.
- Makes it easier to bend higher tones because shorter length scale are preferred so tone intonation does not have the same effect. This is inversely proportional to single fret.
- Has all full access to determine pitch, length, gauge, and string tension in an effort to produce tones that can be explored more broadly.

Use of a scale length with guitar strings

Most conventional guitars nowadays use the 25.5" (648 mm) scale; for example on Fender Strat guitar products. While several others prefer 24.75" (629 mm) scale as it used on Gibson Les Paul guitar products, and also medium length 25" (635 mm) scale used on Paul Reed Smith guitar products. Based on the size of

the standard strings 0.009" - 0.042" to 0.011" - 0.056", both string set sizes are lighter and some are heavier. It can be seen when we set to EADGBE tuning standard, then the heavier gauge set will have higher voltage than the lighter gauge set, which increase the tone but make it more difficult to bend. But when drop tuning the string E to D or even C, it can get very loose and not ring. When we add string 7 or even string 8 that are tuned to B or A and F# or E respectively, it is almost impossible to get a good tone, intonation and string tension on a scale of 25.5". Therefore, it needs to be a solution or innovation so that all aspects of tone can be fulfilled if using a single fret system. Otherwise, Strandberg Boden 8 string guitar products which have a final length scale of 28" for the string 8 and an initial length scale of 26.5" using 0.009" - 0.042" strings will get a very good tone even when dropping the string 8 tuning to E and even with 0.010" string size can still get a good tone Strandberg (2020).

CONCLUSION

With the innovation of the multiscale fret concept, it is hoped that more guitar luthiers will develop ergonomic guitars with their own signatures so that more ergonomic guitar variants will be found in the local market in the future. In essence, making a guitar is not just about an aesthetic structure of the guitar body which is the main point, but also the quality of the tones that can be more explored. A guitar that is able to minimize the risk of repetitive injuries and comfortable to play also becomes more value in the design and manufacture of an ergonomic guitar that can make people interested in playing it so that it is expected to become a musical instrument that is friendly to humans.

Otherwise, it is not necessary to be misunderstood about conventional fret system which are considered to be poor. However, conventional fret are still widely used by guitar luthiers. The multiscale fret concept is only a new concept to make ergonomic guitars. The use of this concept depends on the perspective and needs of each individual. For those who want to push the limits of creativity in the complexity of musical harmony, the multiscale system is an answer to your questions, both for guitar luthiers and musicians.

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