Jordan Sand

A Three-Dimensional Geography of the Double Bass

Performance Paper

Video of presentation can be found here

Instrumental Geography: Illuminating Relationships through a 3-Dimensional Interface

Jordan Sand

NTNU, Trondheim, Norway
Jordan.sand@ntnu.no

Abstract. This paper presents a new three-dimensional way to map pitch on the double bass. The project is designed to illuminate spatial and intervallic relationships between two pitch systems, or "layers" of the instrument – stopped notes and harmonics – in order to facilitate a more polyphonic, harmonically-varied approach to composition and improvisation within a composite pitch system. After contextualizing the work within the instrumental field, overarching goals and early versions of the mapping will be presented, followed by the processes taken to develop it to this point, and some of the coding structures used to render digital visualizations. Due to the in-progress nature of this project, this paper will also envision future versions of and uses for the mapping.

Keywords: double bass, visualization, harmonics, geography, choreography, instrumental research, performance

The MAP is the interface

The fingerboard of the bass spans over 600 square centimetres of blank playing surface – for reference, that's almost twice the area of the cello's fingerboard, four times that of a violin, and just 10 cm shy of the length of a piano keyboard. We find no frets or inlays, few tactile anchor points for the hand, and forget about standardized spacings from bass to bass! On this unwieldy instrument, pitch is a wilderness. Even the most fundamental musical functions rely upon a precise, comprehensive internal map: the bassist's indispensible interface.

First formed in the mind's eye, this map structures the fingerboard's blank space into collections of points and relationships – a *geography* – which then guides the design of intricate *choreography*, sequencing the reflexive recall of exact physical spaces. What we practice "seeing" on this instrument eventually sinks into the body, transforming from visual to kinaesthetic. We *perform* the interface internalized.

The map is assembled from one basic unit: a set of coordinates, or a *node*. Defined as "a point in a network or diagram at which lines or pathways intersect or branch", in bass lingo a node marks a point on the string where one presses or touches to sound a musical note. On the fingerboard, I see constellations of these nodes crystalizing in space, guiding the shape and movement of my left hand. But unlike the flat diagrams of astronomy books, my constellation springs from the page. I envision the nodes of the bass as if you could step inside them, witness to their prismatic depth.

How does a third nodal dimension occur on the theoretically two-dimensional playing surface of a fingerboard? In addition to length (of string) and width (repetition of strings side-by-side), there is an undeniable dimension of height, or elevation, resulting from two "planes" or "levels" of playing. We may fully depress the string against the fingerboard, shortening it to change the pitch – this lower level produces fundamental, or "stopped" notes. Or we can lightly touch the string at its natural elevation, causing it to vibrate in equal divisions – an upper level, producing natural harmonics.

In practice, the distinction is subtle – only about 8mm change in elevation between a stopped note and its cohabiting harmonic. From the outside, the dimensions of length and width pack more of an empirical punch. Perhaps the player, too, may overlook elevation. We mostly experience the distinction between levels as a nuanced tactile shift. After all, both emanate from the same string, which is, for all intents and purposes, one-dimensional. [1]

But another factor, more conceptual than mechanical, may confine the map to two dimensions. Most bassists habitually view harmonics as sort of an isolated phenomenon, an unorthodox "extended technique", rather than a ubiquitous, fundamental characteristic of the instrument. Even with deeper understanding, the widespread tendency is to use harmonics and stopped notes independently, as if shifting gears on a car, releasing one to engage the other.

In truth, the two pitch planes work as one integrated machine: a phenomenon unique to the bass. Its long fingerboard, low register, and resonant build render its natural harmonics playable throughout the entire string length, pitched roughly in the advantageous range of the human voice, and acoustically supported.[2] Thus, unlike smaller stringed instruments, the bass's harmonic series is an anomalously robust and omnipresent pitch system, ready to rub elbows with stopped-notes in every single hand-position known to mankind.

Bertram Turetzky, writing in 1989, observed that:

> "One seldom-used technique with extensive potential is the double-stop combination of natural harmonics and stopped notes. The sound is unique, often not having primarily the character of two notes, but rather something fused, almost "electronic"…… the technique releases the contrabass from being merely a "one line" instrument. There are somewhere between one and three hundred such possible combinations, depending on the size of the performer's left hand and the extent of his or her proficiency with higher partials." (Turetzky, 137-138.)

When I first stumbled upon this quote, I laughed aloud in my empty new studio at NTNU. My teacher's teacher summarized my obsession with this instrument a year before I existed. Such combinations are more widely explored now, perhaps,[3] but still used sporadically, unsystematically – for, in spite of the ample scholarship on bass harmonics, we seem to lack a thorough geography, nay, *topography*, of this unique composite pitch system, and the utter bird's nest of intervallic relationships forming therein.

There might be a method to the madness in there, but we can't get at it with two dimensions. A flat map is built to track one line or layer at a time; indeed I've yet to come across a position chart, map, or tablature of the bass that *wasn't* two-dimensional, as the vast majority of bass playing is currently linear.[4] But what of an approach to the bass that is primarily chordal, using both pitch layers simultaneously at every moment? In order to systematically explore the hundreds of intervals occurring across strings *and* levels – the raw materials of my music – I actually need a *model*, not a map.

By illuminating the full scope of this insane interval machine, I'm hunting for new pitch combinations within my primarily dyadic, polyphonic approach to the bass. I am compositionally motivated. I want to unleash its idiosyncratic counterpoint and complete harmonic palate, in the hunt for more color, movement and complexity within my writing. It's essential to do so through the lens of practice – what is physically playable on the bass?

To that end, my secondary motivations are pedagogical. A model helps to bypass rote familiarity and objectively discover new combinations; but then how do I learn to play them? A thorough geography will help me approach this task methodically, to more successfully develop and internalize custom choreographies. Then, turning outward, I will be better equipped to communicate an integrated method for the bass' composite pitch system.

This project is intended as a practical, instrument-specific tool. It neither replaces nor departs from the previous work and raw materials of fellow bassist-composers, but is meant to synthesize a pedagogical approach to natural harmonics

[1] Auditory Neuroscience: Making Sense of Sound, pg. 10

[2] We may also rejoice that the bass is a bowed instrument, a bow a tool that gives us more finite control over a broader range of harmonics than pizz.

with a different lens, within an alternative aesthetic context, focusing on expressions and organizations of pitch over breadth and variety of timbre. It is not meant as an objective research in acoustic properties. Likewise, we're not dealing yet with issues of tuning or temperament, as will certainly arise later, nor correlated technical studies of the bow, although in practice this is a stringent, prerequisite factor.

For now, I provide a scaffolding for the on-going development of a left-hand interface, beginning with half-scale technical drawings, followed by digital visualizations built with the Python coding language. This foundational project-within-a-project at NTNU is meant to geographically illuminate the full spectrum of pitch on the bass, discover and organize intervals, guide the development of new left-hand choreographies, inspire composition, and prepare to set the composite pitch system of the acoustic bowed bass into dialogue with electronics and chamber ensembles through my creative practice. I hope that as it develops, this project can bridge a gap in a collective interface, motivating others to explore the double bass anew.

Evolutionary background

Bassists place much pedagogical emphasis on *how* to visualize, map and choreograph this instrument. Considering the fingerboard's plentiful room for error, we must obsess. But another factor rivets us to the map: double bass is a veritable jack-of all-trades undergoing rapid evolution. *How* we map and choreograph the fingerboard has everything to do with what we each perceive in this bizarrely all-purpose instrument. As in other disciplines, we map according to a specified purpose – in what genre or style are we working, in what ensemble role, with which aesthetic priorities?

The options overwhelm: bass propels bluegrass and baroque, Stravinsky and Count Basie, free jazz, rockabilly and the romantic symphony orchestra. It increasingly shines as a solo instrument. Composers broaden and enrich the repertoire, and trailblazing improvisers stretch its timbral and harmonic palette. With advancing techniques and a rapidly globalizing pedagogical network, our collective level of playing keeps rising, expanding notions of what the bass can do.

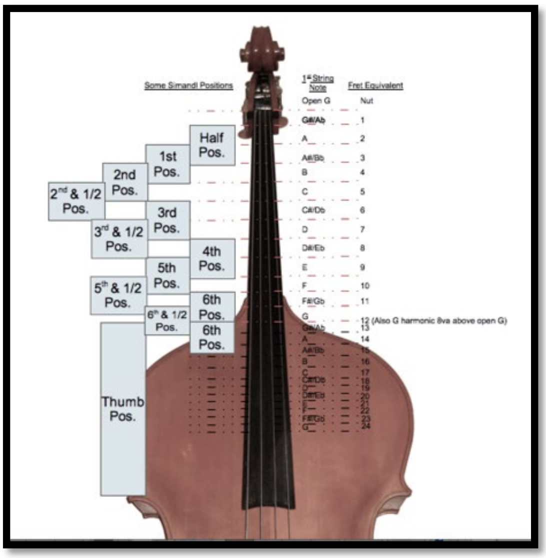
Bass thus seems to be undergoing a Renaissance, "a period of explosive development similar in a general way to that of the other string instruments in the 19th century". [5] This has spurred a wealth of geographies and choreographies, each deeply correlated to the purpose at hand. It is useful to present a brief outline[6] of those that have coagulated into a pedagogy – specifically a "mapped" pedagogy, centring on a visual-spatial organization of pitch yielding left-hand positions and codes of movement – to demonstrate how harmonics increasingly work their way into a technical understanding, and then an aesthetic approach, to the bass.

In the United States, two contrasting pedagogical methods are widely used. From 1881, Franz Simandl's method develops orchestral technique, demarcating twelve distinct positions in the first octave of the string for strength and control in low registers. For Simandl, bass is the dry, punchy platter on which we put the orchestral cake. Alternately, François Rabbath's streamlined, soloistic fingerboard organization marks fewer, larger positions for more rapid vertical movement along the entire length of the string, with left-hand choreography designed to preserve resonance and a "singing" continuity for the bow.

Published in 1977, Rabbath's positions were likely the first to be intentionally organized around natural harmonic nodes (their sounding pitches are shown on the right in Fig. 2). Harmonics also guided bow placement – he pinpointed the point of contact for most optimal resonance, or "son premiere" around a harmonic node just past the end of the fingerboard. An autodidact turned virtuoso, François likely found that the unwavering coordinates of lower-partial harmonics provided an anchor during his decades of self-directed study.

[5] Paul Brun: *A New History of the Double Bass,* Paul Brun Productions, 2000, p. 92.

[6] It should be noted that I come from a specifically American lineage of training, so my points of reference may not reflect the pedagogical progression experienced by a bassist completing training in other parts of the globe.



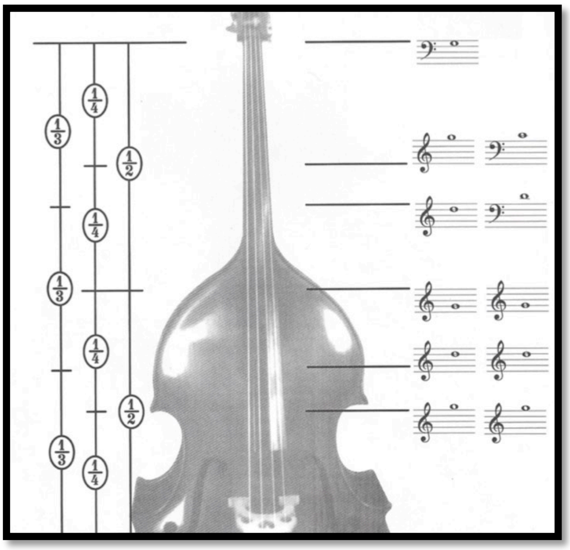


Figure 1. a Simandl position chart (Christopher-j.net)

Figure 2. Rabbath position chart (Vance, page 5)

With increasing reference to harmonic nodes, new mappings have condensed axioms of Simandl and Rabbath to support the virtuosity of new generations, such as David Allen Moore's system of *Fractal Fingering* (2019). Moore divides the string into 6 equal parts. When repeated, this same physical distance contains stopped-note intervals of a m3rd, M3rd, P4, P5, and P8, respectively (Fig.3) – a phenomenon of fractal mathematics, around which Moore builds detailed hierarchies of position and movement, informed by years of methodical work decoding the advanced, idiosyncratic left-hand techniques of bass virtuoso Edgar Meyer. Hence, we have an interface built for precision and speed in soloistic, stopped-note playing, emulating the capabilities of higher-pitched stringed instruments. [7]

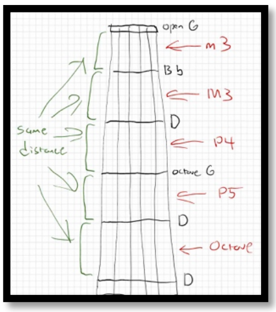


Figure 3. Diagram of the principle behind *Fractal Fingering* (provided by Jason Heath, doublebassblog.org)

As modernizing musical styles increasingly focused on timbral diversity, harmonics moved from a tracking device to a destination and began to attract more detailed research. Mark Dresser's fastidious video-mapping *Guts* (2010) breaks

[7] The majority of my formal training came from this lineage – a distinctly American school of technically analytical playing and teaching, deeply informed by the philosophies of movement and sound production of François Rabbath. This technical community was spearheaded in the 1980s by Paul Ellison of Rice University, and now includes performers and pedagogues Nicholas Walker (Ithaca College) Ali Yazdanfar (McGuill University) Scott Dixon (Oberlin & CIM) and David Allen Moore (USC).

open the Pandora's box of harmonic techniques, sounds, and systems on the bass and demystifies their acoustic premise, nodal locations and musical potential. *Guts* is perhaps the first documented method to systematically reveal the sheer, applicable omnipresence of harmonics throughout the entire fingerboard.

Dresser asserts that an understanding of the natural phenomena of string vibration is central to his creative process of exploring sound on the contrabass.[8] Harmonic nodes form his grammatical super-structure, supporting a whole dictionary of more complex, personalized harmonic techniques,[9] cultivated via decades of experience in jazz, improvisation, and contemporary music. Many improvisers and composer-performers share this lexical approach to the instrument, grounded in expanding one's timbral palate.[10] By assembling pedagogy around this grammar, Dresser gives modern bassists a pivotal technical tool, transforming our understanding of the instrument across musical communities.

Dresser's work augments that of his predecessor at the University of California San Diego, Bertram Turetzky, who mapped harmonics along a single axis indexed to staff-notation (Fig.4). Turetzky mapped as far as the 10th division of the string, a fairly high partial. Dresser dared up to the 19th (see Fig 5).

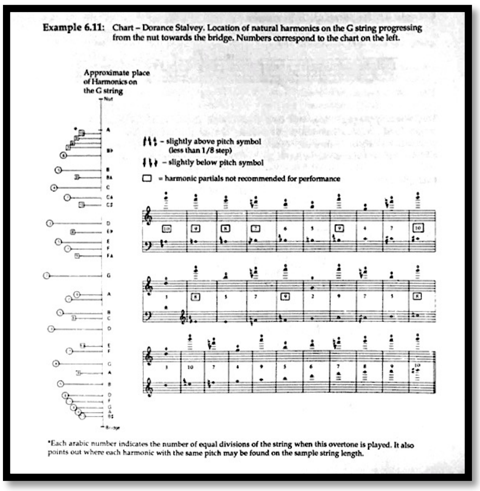


Figure 4. The Contemporary Contrabass (Turetzky) pg 109

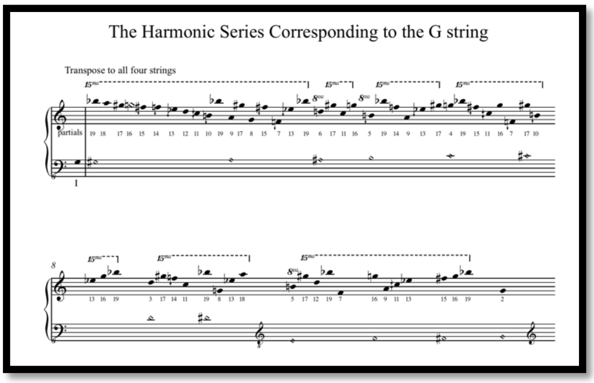


Figure 5. Excerpt from Mark Dresser's document "Harmonic Correspondence – G string" accompanying *Guts*

Both documents show essentially the same information, mostly differing in extent and format – a nice example of the bass community's collective interface, wherein both lineage and innovation are upheld. No two mappings are mutually exclusive, creating room for dialogue and (sometimes rapid) evolution.

Even methods as seemingly disparate as Dresser and Rabbath's tread much common ground. In their case, as in many cases, it's the harmonic – for a harmonic's location is a tenacious mathematical fact. Simultaneously a guidepost, destination, and fundamental principle of physics, harmonics intimately affect all sound produced on the double bass. Our collective mapping becomes increasingly oriented to them for good reason. They offer us a thread of continuity, a touch-point between varying geographies.

[8] from the accompanying written notes to *Guts*
[9] artificial, multi-nodal, or flautando harmonics; subharmonics, multiphonics, or bitones
[10] Joelle Léandre, Barry Guy, Stefano Scodanibbio, Jiri Slavik, Håkon Thelin, I could keep going, the generations of bassist-innovators keep rolling in

Interestingly, they're also the fault line along which new geographies form – as in, you map according to your treatment of harmonics, and in turn, one treats harmonics according to how one perceives the instrument's essential character. Like others, the character I perceive originates *beyond* the bass, in something sonically larger than the monophony of Simandl's cake platter, Rabbath's singing belcanto, Moore and Meyer's bigger funkier violin, or Dresser's explosive dictionary. To me, the bass is an organ – a sound that engulfed me weekly for almost 20 years, while growing up attending a Presbyterian church.

Around age twelve I absconded from violin to bass: no coincidence, in retrospect. Its resonant, overtone-ridden bow sound, so evocative of those engulfing pipes, mesmerized me. Later I became engrossed in its peculiar timbral nuances, almost as varied as the stops of an organ, and the latent harmony and polyphony between its pitch layers, like the organ's multiple manuals (keyboards). Its an instrument I can live inside, that owns the room in all directions, standalone and mysterious.

Harmonics breathe life into this sonic blueprint, but bass may transform into a chordal, multi-line instrument only when they are treated as a fully-fledged pitch system, in synchrony with stopped notes. I've been chasing this transformation for some years. My approach has the most in common with Norwegian bassist Håkon Thelin, who's solo compositions display dense polyphony, and his mentor, the late Stefano Scodanibbio, whose live presence was compared to that of an entire orchestra[11] – both composer-performers working closely with the instrument's composite pitch system. Thelin writes beautifully of the technical inner workings of Scodanibbio's music:

> "The novelty … lies in his refined use of harmonics on every part of the string, also in the low and middle positions of the fingerboard. In his music, narrative and rhapsodic phrases are formed through an interchanging of ordinary tones and flageolets. This constantly changing motion between low and high sounds creates multi-dimensional rooms where sounds and fragments of melody can evolve."[12]

Thelin goes on to claim that the evolution of the natural voice of the bass, with Scodanibbio's use of harmonics, is drawing near to completion.

> "The full potential of harmonic sounds on the double bass, as it is realised by Scodanibbio and others, may very well be *the final step in the development of the historical double bass.* All major divisions of playing techniques have now been defined, and exploration of the natural inherent possibilities of the instrument itself has reached its final evolutionary stage... Indeed, it is within its expressive range of timbre that the modern double bass has truly found its voice. "[13]

I would add that within this final evolutionary stage, we must not stop at viewing harmonics as a key to timbral plurality, or as linear melodic tools forming interchangeable melodic fragments. They are the flip side of the pitch coin, the omnipresent parallel universe, the arm outstretched from the bass to the organ. They are what make the bass larger than the sum of its parts, and their role in the duality and simultaneity of pitch and place is one of the least explored yet most fundamental, natural, inherent possibilities of the instrument.

While using I am using the same raw materials, in my work the evolutionary tree again branches off[14], with voice as the catalyst: I sing with my bass. Both the presence and orchestration of voice has drawn a primarily chordal harmonic expression from the instrument, even as the role of voice changes in my music. I used to melodically and timbrally forefront the voice, with chordal bowed bass accompaniment. Now I want to subvert these hierarchies (the singer-songwriter factory-default), and sink the voice *into* the instrument, weaving melody and harmony equally between stopped note, harmonic, and voice, exploring the tension and release of consonance and dissonance.

[11] Referencing a quote from Terry Riley regarding Scodanibbio's playing, from "Press" on stefanoscodanibbio.com
[12] Håkon Thelin, "A Folk Music for the Double Bass" pg. 2
[13] Ibid., pg. 2

This search for richer three-part harmony, homophony, and polyphony has asked more and more of harmonics on the bass *as a pitch system*, contributing to a wider *bed of sound* within which to sink a human sound. Voice is indeed lurking there in my blueprint: the hymn-singing congregation melting into the organ, the expressive power of something biological yet fused, almost "electronic" – the sound much larger than the sum of its parts.

I wax poetic in order to collect energy for the task ahead, illuminating this immense galaxy on the instrument. I suspect that, if I step inside its many constellations, the whole character of the bass could evolve for me yet again.

Defining goals for the interface

In light of these purposes, existing mappings have some limitations, especially in the treatment of harmonics. Many good resources outline their pitch content, approximate locations, correspondence to stopped notes directly under them on the same string, etc. [15] using mostly demonstration, and various forms of staff notation – but their geographic *mapping* remains incomplete. If and when a map is made, it tends to be linear, vertical, along the length of one string. Second, the scaling is often approximate, imprecise, despite the exacting mathematical nature of harmonic nodes. Most significantly, apart from their use as anchors (ie. the nodes that a lower-partial harmonic shares with a stopped note) harmonics are charted in overwhelming isolation and self-reference, rather than locally or laterally, in deep spatial and intervallic dialogue with both correlating and surrounding pitches.

Why insist on a mapping, anyway? I'm talking about a diagram; a map; a third-party visual-aid apart from human and instrument; a star chart. For me, format is important. Loose position charts, tablature, staff notation, and video demonstrations are like various keys or indexes to an imagined map – they don't fill the function of the map itself.

Remember, this thing is a "wilderness" – no pre-installed points or pathways, as on a guitar, nor broadly-encompassing hand positions, as on a violin. On the bass, to hit almost any new target, you have to *move*; so you must have an accurate mental picture of what you're moving through. To complicate matters, harmonics can be finicky targets. You either hit it or you don't – there's no consolation prize, no "out of tune". In the case of harmonics, there's simply too much at stake to substitute geography for a kind of disembodied short-hand, when actually *plotting* the terrain can quickly orient us. [16]

Another roadblock: when deferring to staff notation as primary pedagogical means, we create several cumbersome layers of translation when it comes to actual pitch content. The fact that bass is already a transposing instrument (sounding an octave lower than it's written pitch), and our current system of notating harmonics is a kind of tablature not correlated to sounding pitch, means that staff notation is pretty ill-equipped to help us grasp the instrument's full range of pitch content across its composite pitch system. Staff notation is just that – notation. A system of symbols or ciphers, awaiting translation. It's quite effective in communicating a series of events in a piece, but proves a poor pedagogical tool, unable to orient us within a composite pitch-field unless indexed to something more direct. In this context, I believe finding a way to communicate pitch graphically would be most effective.

Above all, I am searching for a form of documentation most aligned with the materials in-practice. With this in mind, the first step in the creation of a new mapping was to define some goals.

What information should it contain?

Nodes: Exact mathemathically-derived location of each harmonic node, each stopped note, accompanied by detailed information on pitch (both class and octave) partial number (division of string) and frequency (Hz).

[15] For example, Mark Dresser's *Guts*, Bert Turetzky's *The Contemporary Contrabass*, Knut Guettler's *A Guide to Advanced Modern Double Bass Technique,* Jean Pierre Robert's *Le Modes de jeu de la contrebasse*

[16] How much easier is it to glance at a street map than to remember and follow written or verbal directions? Look at a cross-section of the human body and find your own spleen? And a hundred other rhetorical questions

Intervallic Relationships between: harmonic layer on 1 string, harmonic layer across 2 or multiple strings, harmonic layer and stopped note layer on 1 string, harmonic layer and stopped note layer across 2, 3 and 4 strings – all imaginable combinations, both physically playable as double stops (organized by hand position) and playable as linear intervallic movement with or without a shift.

Hand positions: how to show placement and movement of the left-hand, both influenced by and influencing the expression of this density of nodal information?

References: Should this eventually be referenced graphically to multiple existing schools/ways of organizing left-hand position on the fingerboard, to give others a familiar frame of reference to dive in? Perhaps a question for a later or more pedagogically-oriented version.

Extent: Should it focus on block-position (the area of the bass where the registral content and resulting intervals are most salient to my music) or should it span the entirety of the fingerboard?

What should it do?

Tuning: Should be able to change the tuning of any individual string, which adjusts all pitch information on that string as well as the relevant intervals that string is involved in. Important to note that any geographic information does not change (partial number and location of nodes) only pitch, hz, and intervallic information.

Filtering of information: We should be able to display different organizations of the composite map, in order to be able to visually focus on specific functions or attributes of the system. For example, we should be able to display/activate different data sets within pitch and intervallic information, filtering according to type of interval (show me all the minor 9ths hiding in here!) hand position (show me all the intervals accessible across x number of strings in this hand position) the type of pitch information (perhaps I want to see every node in terms of Hz only) or partial number (to explore the way a certain partial interacts with stopped notes in its multiple locations). Should we be able to isolate all phenomenon within a certain frequency range? Click on an interval and be indexed elsewhere to its staff-notated form?

Sound: Should or could this map sound on its own? At first I considered this unnecessary, but perhaps being able to sonically play around with the possibilities away from the bass but still connected to the geography would be useful. If, in this fashion, I hear an interval I can’t yet produce technically, perhaps this would be horrendously motivating.

Interface: I asked myself early on, is this an interface in the more literal sense of the word? Especially considering the thorough mapping of frequency content, could it eventually receive, organize, or filter signal input? Should it? What would allow this to function as more than a technical or compositional reference tool, and in that case what could it do?

How should it look or be designed?

Design: Should there be two versions? A more simplified 3-dimensional grid version, with cubes and rectangles defining the distances, and the proportions accurate along the X and Y axis, but approximated for the Z axis (which contains the dimension of “elevation” between layers) AND a version truer to life, with the distances and spaces that actually exist between layers and the curvature of the fingerboard and bridge taken into account? In imagining the visual presentation of this tool, it’s a matter of what is most useful or effective, visually, spatially, in-practice.

Perspective: We should be able to drag this mapping around in “3-dimensional” space and look at it from different angles, but the main orientation should be from the angle at which we stand at the bass and perceive the fingerboard in the mind’s eye.

These parameters I have simply transcribed from my chicken-scratch notes, in order to set a detailed stage defining what I was after, and why. To now share the interface in-progress, I will take you along through my early process.

Toward dimensionality – rulers, calculators, and code, people

I began mapping this instrument with a tape measure and a sudden understanding that I had forgotten how to do basic fractional mathematics. Harmonic nodes live at equal divisions of the string. To calculate their exact positions for early sketches of this interface, I would have to do math, specifically division, and we may all sense that a bass player and math make for an unlikely romance.[17] The string length of my double bass is approximately 101 cm, an un-fun number to divide. Also, the biggest paper I could find was 80 cm wide. Thus the story of how I ended up with a model string length of 60 cm, a measurement that followed me off the paper and into the digital realm.

The first objective was to map how harmonics and stopped notes relate to each other on *one string* – and to do so in a way that was immediately grasped by the eye, rather than the intellect:

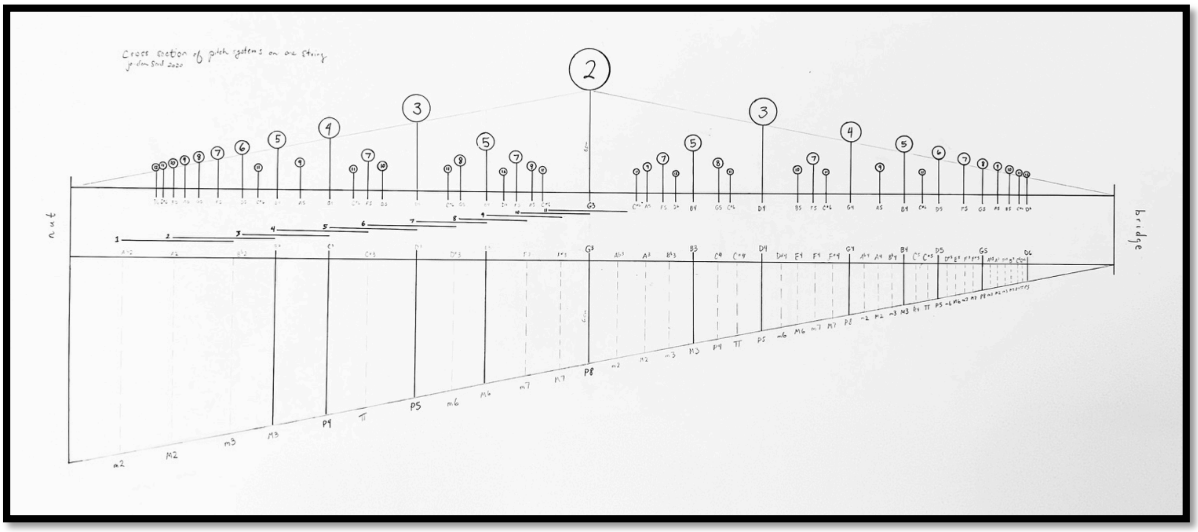


Figure 6. Cross section of pitch systems on one string

The two horizontal lines, at 60 cm long, represent stopped note (lower) and harmonic (upper) planes of the string. The vertical lines extending above and below these planes intersect at exact nodal locations, or divisions, of the string, with lengths proportional to sounding pitch – the longer the line, the deeper the note. By translating pitch to visual size, we can get quick impressions of where unisons or wider intervals may occur. The same is true of the circular markers on the harmonic level, which correspond to partial number. At a glance, we may ascertain where the stronger, lower partials lie (numbers 2-6) and in effect, also understand instantly the relative difficulty to sound each note. This cross-section shows some of the same information as Dresser's "Harmonic series corresponding to the G string". In addition, we get precise, proportional visual information about the location of harmonic nodes, and don't have to transpose or switch clefs in order to grasp intervallic information.

At the halfway point of the string (refer to circular node 2 in Figure 6) the sounding pitch of both the harmonic and the stopped note is G3. Similar unisons continue to occur as we go higher up the string (see, for example, the straight vertical lines descending from partial numbers 3-6 on the right side of this diagram, and note that their lengths match the lengths of the corresponding stopped-note nodes directly below them). However, in the lower half of the string, on

[17] Unlikely – not impossible! I know a bass player who does an hour of probability every morning before a 6 mile run, so… takes all types. (But in my case, it's unlikely.)

the left side of this diagram, the disparity of sounding pitch is much more pronounced, and the intervals wider and less predictable. I am most intrigued by the intervals in this area, and will focus the beginnings of an intervallic mapping here.

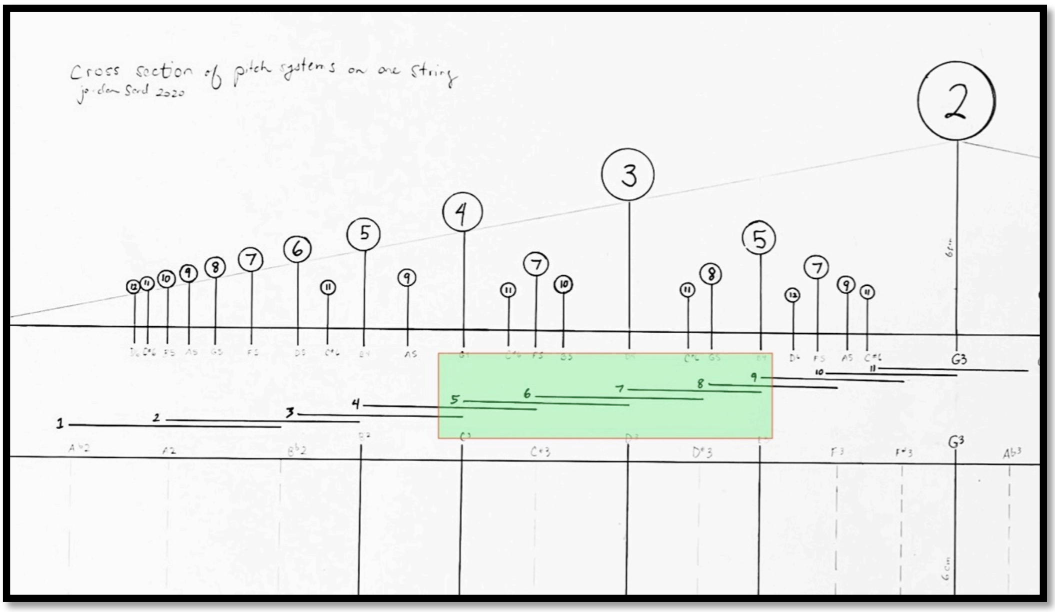


Figure 7. showing the range of hand positions 1-11 with staggered horizontal lines, placed between the two planes

A closer look reveals how we might begin to choreograph the use of these pitch systems together. The staggered horizontal lines represent the range of individual hand settings in the lower half of the string. (11 distinct positions draws from the Simandl approach, wherein displacing the hand by even one half step constitutes a new position.) If I place my hand in the 3rd position, for example, I can reach every note that falls within its range on both planes without moving or shifting my arm. Positions 5, 6 and 7, highlighted in Fig. 7, are especially interesting to me, because they fall right around where the neck meets the body of the bass ("block position") an important tactile anchor for the player. Although I plan to do this for every position of the bass, and across two and three strings, I chose to begin connecting the dots in these three positions on one string to get an impression of just how many intervallic relationships are living in each small territory, as demonstrated in Fig. 8.

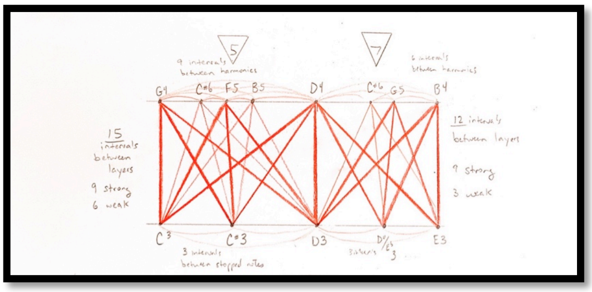


Figure 8. On one string – all possible intervallic combinations between planes within each hand setting

Of course intervals existing on one string, although they have melodic potential, can't be played together as a dyad. The logical next step was to take these connections and explore their workings between two adjacent strings. How many different dyads can be sounded within one hand setting across two strings? Again I am most interested in those dyads occurring between planes (position 5 in Fig. 9), but there are also dyads created harmonic to harmonic (shown in position 7 in Fig. 9) and stopped note to stopped note.

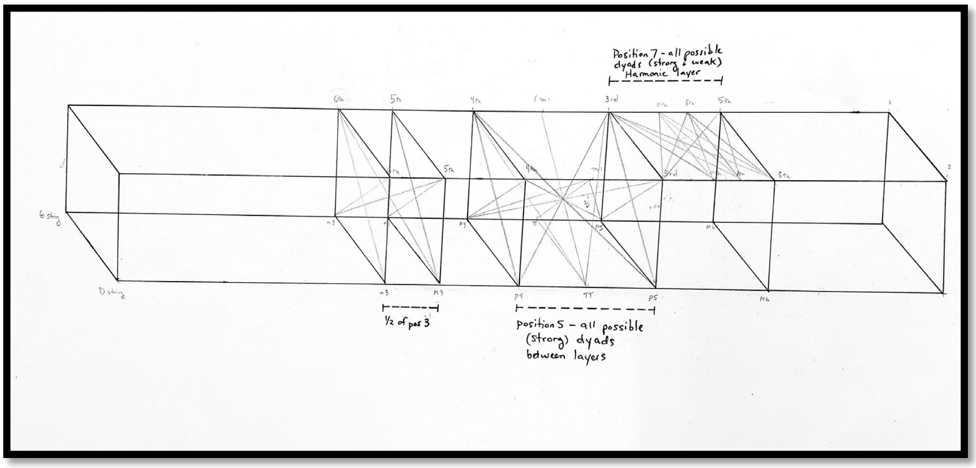


Figure 9. Beginning of a 3-dimensional look at how these pitch materials relate to each other

A static drawing of these relationships across strings quickly becomes a visual mess. To make it clear, it needed to be interactive, in moveable space somehow. I briefly considered making an actual physical 3-d model of it, like middle school science fair. Before I busted out the playdough and pipe cleaners, my supervisor pointed to an online visualization tool (Glowscript.org) that would require a bit of coding – a horrifying prospect that turned out to be a lot of fun, and generated new ideas about the possibilities for this interface.

Beginning anew, I took his suggestion to plot the center of the string, or 2nd partial, as 0 on the x-axis, with the open string (or nut) at -30 and the bridge at 30. Because the harmonic series is expressed in a mirror-image of itself from the half-way point of the string, this would generate data sets that were flexible and easy to keep track of when plotting harmonic nodes.

```
partials = [
    [0],
    [-10, 10],
    [-15, 15],
    [-18, -6, 6, 18],
    [-20, 20],
    [-21.4286, -12.86, -4,286, 4.286, 12.86, 21.4286],
    [-22.5, -7.5, 7.5, 22.5],
    [-23.334, -16.667, -3.334, 3.334, 16.667, 23.333],
    [-24, -12, 12, 24],
    [-24.545, -19.091, -13.6364, -8.1818, -2.7273, 2.7273, 8.1818, 13.6364,
19.091, 24.545],
    [-25, -5, 5, 25],
```

Figure 10. Lists of locations of partials 2-12 along the length of the string (x axis, from -30 to 30)

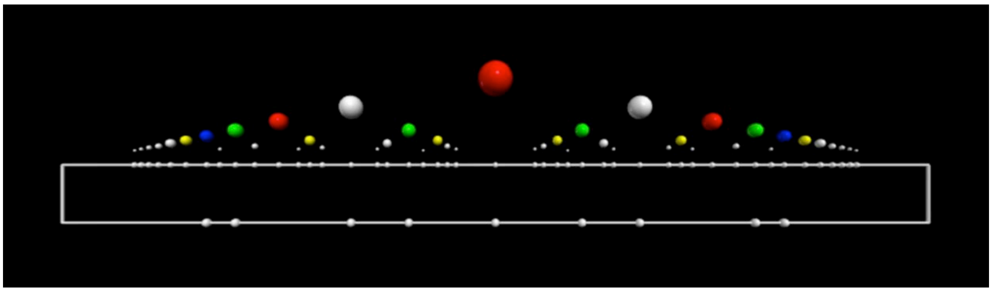


Figure 11. first digital rendering of two pitch planes, one string

Nodal locations on both planes were represented with small sphere objects directly on the string on both planes, rather than as vertical lines that intersected the string as in previous drawings. The larger spheres connected to the harmonic nodes, with sizes and heights proportional to the sounding pitch, were retained for visual tracking purposes. Handsettings were delineated with the color of the curve objects connecting these nodes, rather than separate visual objects. Fig 12 below shows all connections on one string within positions 3, 5 and 7.

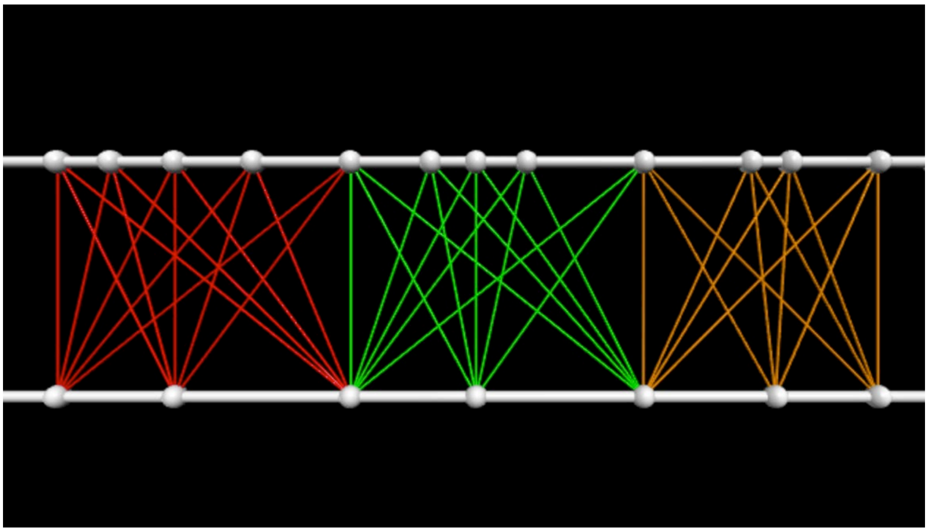


Figure 12. Showing relationships

It is noticeable by now that many complex kaleidoscope-like shapes are being drawn to represent intervals, but no intervals have been qualified as of yet – “that line is a minor 10th, this a major 7th plus an octave” etc. That’s because I would like this interface to automatically compute this for me, because I am lazy, and because there are literally hundreds of these intervals to discover, catalogue, and create with. I quickly realized that my primitive coding skills, barely one week old, would get me far enough to create a visual model. But I did not have the chops to design code that could accommodate my future goals, that was flexible and powerful enough to handle the integration of data sets and allow me to arrange and rearrange it as the concepts behind this interface progressed. What if I wanted to highlight all the minor 9ths available between layers? Or reveal only intervallic connections used in a specific piece, to scrutinize their spatial relationships? How about filtering nodes or connections based on register, partial number, or playability?

So I got out the big guns and called my little brother, who is a computer programmer with a much bigger brain than me, exhibit A:

Figure 13. Little brother, big brain

Over approximately 8 cumulative hours working together on Teamviewer, we were able to build a tool kit that would both render the desired 3-D visualized outcome and set up a "3D" data structure, wherein every partial node is connected or points to the partial series via a series of classes and the objects manifested through them. For the time being, only attributes meant to be rendered visually (such as height, radius, color, points, partial number) are contained within the PartialSeries class. Future drafts of this project can delineate and assign more attributes, such as sounding Hz, calculated according to a flexible fundamental pitch and the partial number, or pitch name and class.

```
class PartialSeries(object):
  '''
  Contains static configuration data for a partial series
  '''
  def __init__(self, number, height, radius, conrad, color, points):
    self.number = number
    self.height = height
    self.radius = radius
    self.conrad = conrad
    self.color = color
    self.points = points


class PartialNode(BaseNode):
  '''
```

```
Represents a single harmonic node and
reference to the partial series that contains it
'''
def __init__(self, series, position, level, string):
    super(PartialNode, self).__init__(position, level, string)
    self.series = series
```

Figure 14. Excerpt of more recent code behind digital rendering of interface

The ability to visually connect clear pitch information to nodal location, in addition to being a prerequisite for automating intervallic calculations, can fill another notable gap in our collective knowledge-in-practice. Although the sounding pitch of bass harmonics has been much documented and notated, it is usually only vaguely understood in practice due to a system of tablature-ish staff notation that references only the playing location, not the sounding pitch, of the note (also convoluted by the fact that bass is a transposing instrument.) We should be able to spatially observe nodal locations of harmonics, together with information about their sounding pitch, in order to have working clarity about the real range of this instrument, which is insane. For example, from this model I know now that the 7th partial of the G string is an F5 – my highest vocal note.

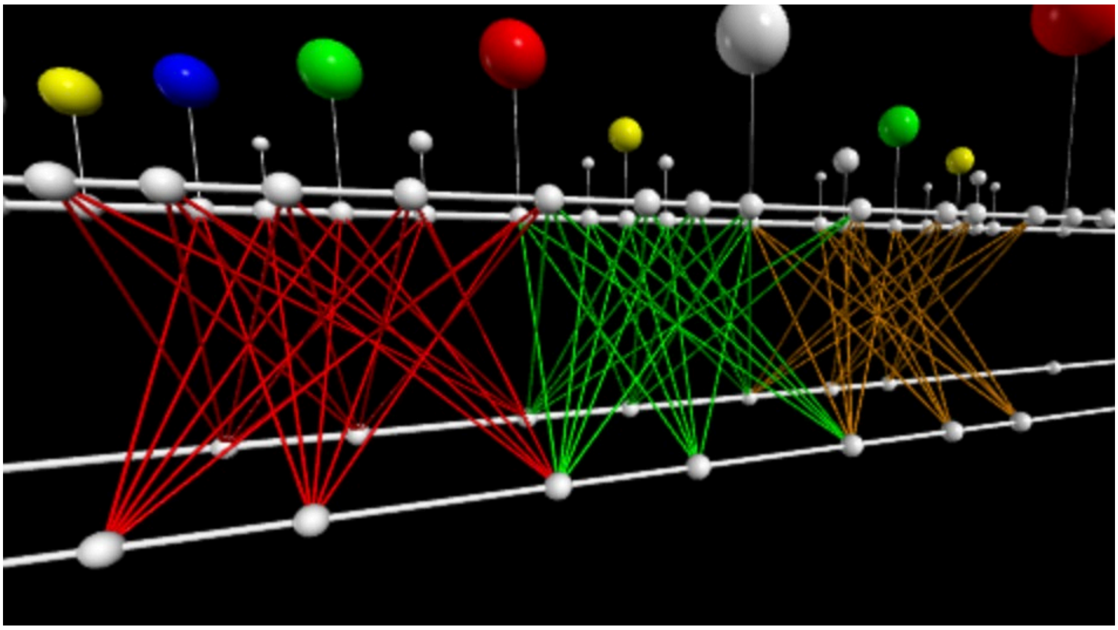


Figure 14. Hand positions 3, 5 and 7

An interesting perspective that Austin contributed was the removal of the fixed plane for the harmonic level along the y axis. What if the stopped note level remained constant, but the harmonics floated in space according to their partial number, and the connections were drawn accordingly, as in Figure 15? It was interesting to experiment with the impact that different visual organizations of the information could have on my relationship to these hand positions, when looking at different versions of the diagram with bass in hand.

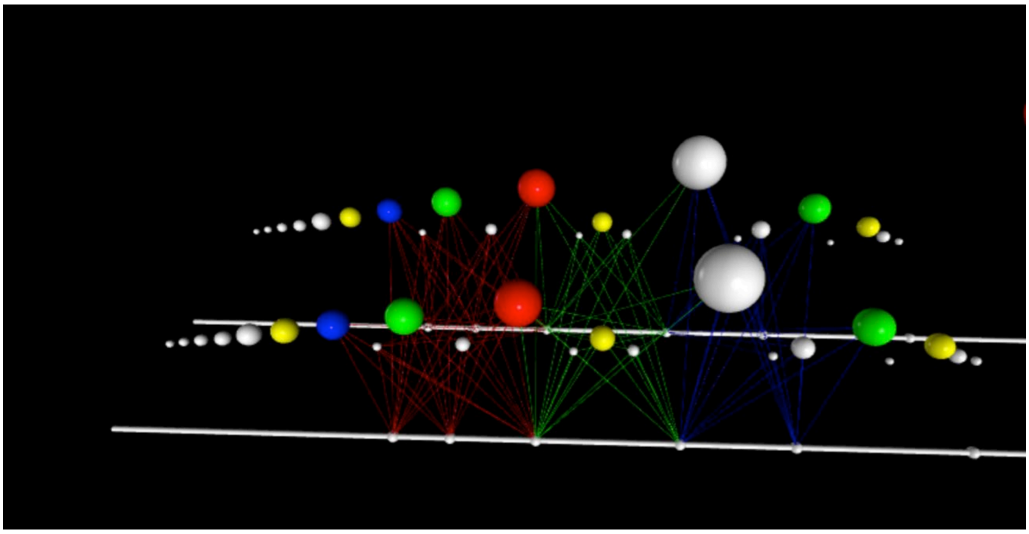


Figure 15. A variable height to visualize nodal locations and relationships, no fixed “harmonic plane”

Surely all these lollipops don’t have anything to do with actually playing the bass? What is this good for? The answer is, almost nothing without the further integration of pitch information, extreme flexibility in examining and filtering information, and, most importantly, a lot of energy spent translating newly revealed spatial realities into the body and instrument in practice. Precise choreographies must be developed – not just of the left hand, in fact, but of the bow as well. Harmonics and stopped notes require very different bow speed, placement and pressure. One needs an extremely nuanced and accurate approach in order to simultaneously sound two disparate beasts across many octaves. Existing left hand positions, designed primarily for stopped note playing, may only go so far to express and control a composite pitch system. Many upper partial harmonics exist in smaller, more irregular spacings that our hands are not used to in lower positions, and must be practiced with hand settings developed specifically for them. In my playing, these choreographies have been partially developed through intuitive, obsessive stubbornness, but there is much deeper, more organized work to do regarding the development and documentation of choreography. This model will provide a basis for this work.

Further work and future versions

Future versions will integrate data sets (pitch name and class, partial #, hz, handsetting) and become more interactive. Could this have implications in live processing, or help to design or automate customized EQ for these complex resonances in live performance? How, and under what circumstances, will it impact my or others’ compositional approach to this instrument? Could there be automated compositional applications of this interface? Could it be used as a graphic mediator or interface between the acoustic presence of the bass and its amplified/electronic equivalent?

There are many pipe-dream applications of this interface that I will enumerate in a later version of this paper, but they basically come down to two categories: How could this project develop into an actual electronic interface, mediating the acoustic signal of the bass with an amplified or live-processed realm? And what potential could it have to automate or randomize playable compositional frameworks with these pitch materials – in other words, in addition to showing what’s there, helping the mere mortal to imagine what could be created with it?

All brainstorms aside, the most important and immediate next step is to apply the map to the terrain and *play.*

Acknowledgements. Thanks to Øyvind Brandtsegg for much patient guidance, and to my brother Austin Morton for his engaged and spirited collaborations.

References

Christopher-J.net. "DB-11: Position numbering on the double bass". Jan 13 2016. https://christopher-j.net/tag/beginners-course-bass/page/2/.

Dresser, Mark. *Guts.* Kadima Collective, 2010.

Guettler, Knut. *A Guide to Advanced Modern Double Bass Technique.* London: Yorke Edition, 1992.

Heath, Jason. "Fractal Fingering: Review." June 11 2019. https://doublebassblog.org/2019/06/fractal-fingering-review.html.

King, Andrew et al. *Auditory Neuroscience: Making sense of sound.* The MIT Press, 2011.

Moore, David Allen. *Fractal Fingering.* 2019. courses.discoverdoublebass.com.

Scodanibbio, Stefano. "Press". *Stefano Scodanibbio.* http://www.stefanoscodanibbio.com/index.htm.

Thelin, Håkon. "A Folk Music for the Double Bass." *New Techniques – New Works.* NorgesMusikkHøgskole. The Norwegian Artistic Research Programme, 2011.

Turetzky, Bertram. *The Contemporary Contrabass.* University of California Press, 1988.

Vance, George. Costanzi, Annette. *Progressive Repertoire for the Double Bass, Vol.1.* Carl Fischer: 2000.