

Musical Instrument Construction and Repair

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Figure 1 - Close-up of the classical guitar I made in Argentina.

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1. Djembe Construction in Santiago Chile



Figure 2 - Initial hollowing of the djembe.

In Santiago, Chile, I found an instrument maker at an art village. In exchange for teaching him how to setup a website for his store, he taught me how to make an instrument. I would have wanted to make a Charango, but my travel plans restricted the time in Chile. Therefore, we decided on a djembe.



Figure 3 - Progression of carving. The drum was hollowed out by hand from both sides.

I carved it by hand out of a tree trunk. This was my first experience using wood chisels and other woodworking tools. Thus the simplicity of a drum seemed like a good introduction. In reality, the aversion to power tools turned this project into a challenging and physically demanding endeavor. I worked on hollowing out the center from both sides. It was a beautiful day when I saw through it.

Once the final shape was acquired and the surface sanded, it was time to apply the finish. A lacquer was applied with a rag (Figure 4). Three coats were necessary with an hour drying time in between the first two and then overnight before the last coat.



Figure 4 - Final shape (left). Applying the finish (right).

It was then time to install the membrane, which is goat hide. The rim is a round metal circle. Luckily two were found that were the right size from one's he already had or else we would have had to bend and weld a new bar of metal for the size of my djembe.



Figure 5 - Rim of djembe before placement.

The hide was held taught between the two rims using string to sew the excess in a star pattern. Then a thicker synthetic string was used to tie the top rim to the middle of the djembe. This was also the way to later tighten the membrane and tune the drum.



Figure 6 - Setting the drum membrane (left). Sewing the string around the rim (right).

2. Classical Guitar Construction in Buenos Aires, Argentina

In Buenos Aires, Argentina, I found a luthier (person who makes stringed instruments) and took a private course to make a classical guitar. He was well stocked with materials acquired from other luthiers or imported. The key to the body of the guitar was that the wood be dried for a minimum of five years such that it would obtain an equilibrium of moisture before being joined. Otherwise, the wood would expand/contract and cause stress failures. I chose wood from alerce trees for the front and carob trees for the back, both of which are found in the Andean mountain range. That way I would have a guitar as a symbolic reminder of my trip in South America. The following is an abbreviated account of the process.



Figure 7 - Beginnings of my classical guitar. The front and back of the body are made from two pieces joined in a press made of wedges and string (right).

My first struggle, which no picture can portray, was the amount of sanding necessary to get the wood to the correct thickness. Then the junction was filed to match and glued in a press made of wedges and string (Figure 7).

The neck of the guitar was reinforced in order to prevent warping. A trench was carved down the middle (Figure 8) in a long “I” shape and filled in with rectangular pieces of a dense wood. If the entire neck had been made from this wood then the guitar would become too neck heavy. My experience carving the djembe came in handy because it was the same techniques with chisels, only more delicate.

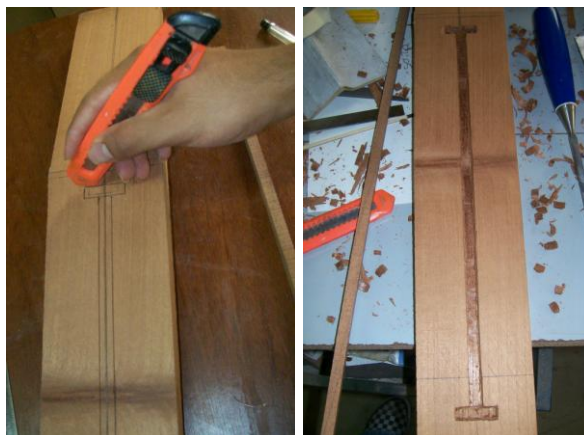


Figure 8 - Reinforcing the neck by adding a piece of dense wood down the middle of the neck.

The guitar rosette is the decorative element made of tiny pieces of colored wood. It is placed around the soundhole on the front of the guitar. To embed the rosette a router was used to carve out a circle into the front soundboard a few millimeters thick (Figure 9). A special jig was used in conjunction with the router to obtain the circular shape.



Figure 9 - Guitar rosette. A router was used to create the trench for installing the rosette. A black colored wood glue was used to match the dark tones of the wood. Any gaps were filled in with small pieces of wood and carved into place (bottom right).

A dark colored wood glue was used to join the rosette in order to match the dark tones of the wood. Places on the trench where the rosette was not a perfect fit needed to be filled in. If the gap was wide enough, a piece of wood was wedged in and glued. In other places, a mixture of glue and a dark wood powder was used to fill in the spaces.

The insides of the sound boards have spines for structural support, such as down the center. On the front piece these spines affect the resonance of the guitar.



Figure 10 - Template for the spines (left) which are directly under the front soundboard (right).



Figure 11 - The heel where the neck is joined with the body of the guitar (top).

The neck of the guitar was joined with the “heel” where it would later be joined with the body. The neck and head of the guitar were the places where I added the most personal touches to my guitar. The neck was carved to the thickness which I chose from my personal preference. Classical guitars usually have very wide thick necks. I prefer thinner and made more of a “v” shape. The head of the guitar was carved with a design of my creation. A sine wave reflected about the middle and an M right below that M, for Munoz.



Figure 12 - Drilling holes for the tuners (left). Filing my design onto the head (top right). Carving the neck (bottom right).



Figure 13 - Jig used to form the sides of the guitar.

In order to bend the sides of the guitar into the final S shapes they are first soaked in water and then pressed against a hot piece of round metal. Afterwards the piece is clipped to a jig which has the desired shape and left overnight to hold that shape.

To glue the sides with the front and back, masking tape temporarily held them in place as the glue was applied. Then when everything was in place a rope was wound around the body (Figure 14).



Figure 14 - Gluing the sides of the guitar. To hold them in place I wrapped the entire body with string.



Figure 15 - Clamping down the fretboard.

The fretboard was set with clamps and rubber bands. A table saw was used to carve the spaces where the metal frets would go. A thick adhesive was used to set the frets. Then the guitar was sent to be coated with a polyurethane finish. While it was out, the bridge was prepared. The rectangular space where the bridge would be installed was taped before sent out for coating. Once we got the guitar back the bridge was glued using a long c-clamp.



Figure 16 - Bridge (top left). Setting the glue for the frets (top right). Installing the bridge (bottom).

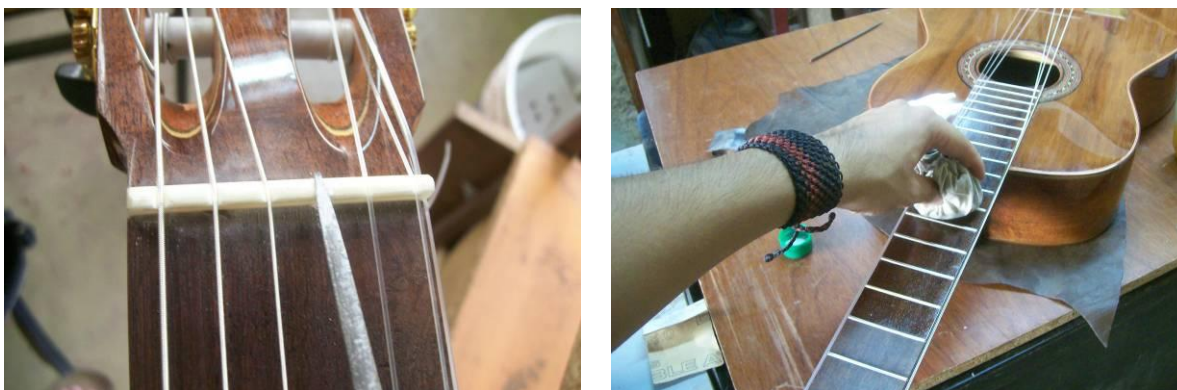


Figure 17 - Filing the bone at the nut (left), and applying a protective coating of oil to the fretboard (right).

The two nodes of the guitar (at the neck and at the bridge) where the strings are suspended are made of bone. An indentation was filed into the one at the neck so that the strings rest comfortably in position. Without this the strings would slide around and break from the sharp edge. Finally, the fretboard was soaked with an oil for protection.



Figure 18 - Playing my classical guitar two days after it was finished in Buenos Aires.

3. Electro-acoustic Cajon Construction

The cajón is a drum with origins in Peru and popularized in flamenco music by Paco de Lucia. The construction of my electroacoustic cajón began with the disassembly of an old bookcase that was stored in my garage. The most difficult process was sanding away the thick layer of white paint.

The sides which are $\frac{3}{4}$ " hardwood were joined using woodglue (Figure 19). The soundhole was cut using a router. The drum membrane is $\frac{1}{4}$ " plywood which is screwed onto the sides of the front face. I will experiment with different thicknesses of plywood to arrive at the correct thickness by preference of playing response and sound quality.

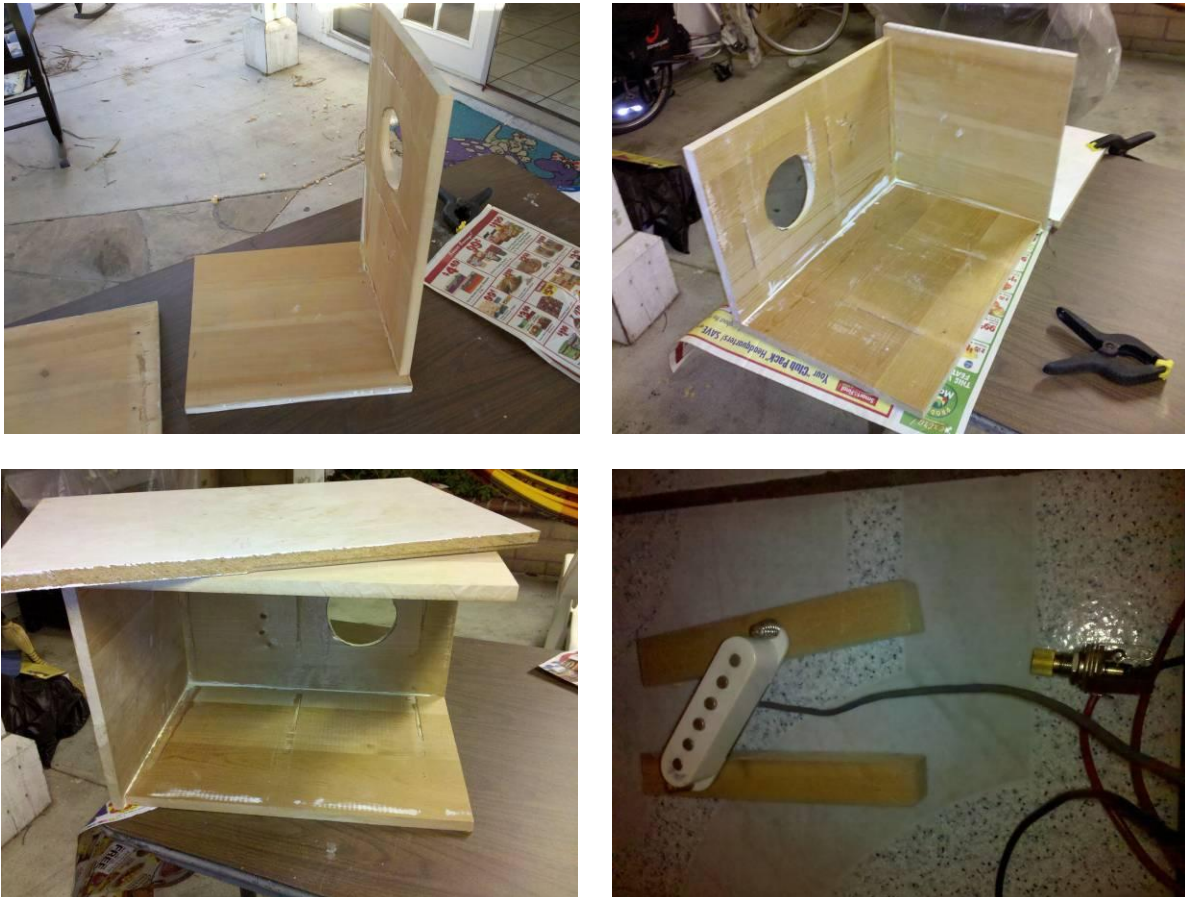


Figure 19 - Cajon construction steps starting from top left. Bottom right shows guitar pickup and 1/2" connector before mounting.

A property that can vary, besides size, is the placement and type of snare. Some use semi-rigid beaded snares that press onto the drum membrane. Others tie metal strings behind the drum membrane. I chose to do the later using old broken electric guitar strings and thus continuing with the theme of reusing materials to create my instrument. To turn this drum into an electric instrument, I took a guitar pickup (also from an old guitar I had) and suspended it inside the cajón such that it will receive the vibrations from the snare strings (Figure 20).



Figure 20 - Guitar pickup positioned behind the "snare" strings (left). 1/2" jack on the back of cajon (right).

The guitar pickup was directly connected to a 1/2" jack which was then mounted on the rear of the cajón. In future versions there would be control knobs in this circuit, but with this prototype all levels and effects are controlled digitally by my laptop. The signal goes into an M-Audio Fast Track Ultra. I am using the program Max/MSP/Jitter to process the signal and add a visual component to the performance.

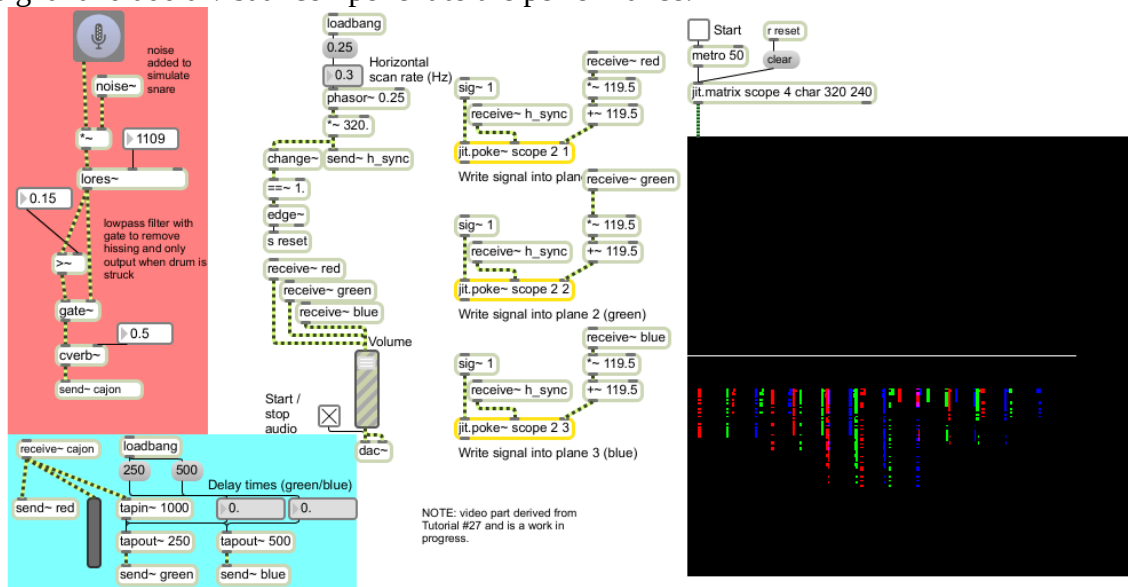


Figure 21 – Max/MSP/Jitter patch work in progress used to process the signal from the cajon. Noise is added to simulate a snare effect. A lowpass filter and gate are used to remove the hiss from the pickup and only output sound when the drum is struck.

4. Bamboo Saxophone Construction



Figure 22 - Bamboo saxophone workbench (left). Sax being played to show scale (right).

In the city of Salta, Argentina, I arrived at a hostel and discovered another guest was making reed instruments out of bamboo. Armed with just string, sandpaper, superglue, an exacto knife, and a handsaw, he made bamboo saxophones and clarinets. At each city he would make a few and then sell them at the local plazas. He taught me how to make them in exchange for me helping him sell them. The one I made is pictured in Figure 22.

The most impressive part of the construction was watching him make the reeds. With only an exacto knife and sandpaper he would make a reed from a piece of bamboo within minutes. From years of experience he had the skill to make the perfect shape and thickness.

5. Bombo Leguero

In the state of Santiago del Estero, Argentina there is a marvelous campground called El Patio de Froilan. Froilan is a bass drum builder of a special drum called a bombo leguero. The name derives from the fact that you can hear this drum from the distance of a league away. The drum has a single strap for carrying it on your shoulder and goat hides as the membranes, one side bald, and the other with hair. The rims are made of wood and tied with thin strips of cowhide. The body of the drum is a single piece of wood made by hollowing out a tree trunk and slowly burn away the center. In addition, Froilan burns intricate images on the sides of the drum to personalize each one.



Figure 23 - Bass Drum. Burning a hole in the rim for tightening the cowhide rope.

6. Charango Bridge Repair

The charango is traditionally made with the carcass of an armadillo, but due to animal preservation concerns, these instruments are now being made entirely out of wood. In Aiquile, Bolivia, I interviewed a charango builder and purchased one of his charangos. Unfortunately, when I later traveled to Buenos Aires, Argentina, the hot humid summer caused a failure in the glue holding the bridge to the body of the charango.



Figure 24 - Space where bridge was attached (left). Sanding away the previous adhesive (bottom). Replacing the bridge (right).

I had to sand away the previous adhesive before reattaching the bridge. I made crosshatched grooves in the area of the charango where the bridge would go before joining the pieces. Instead of wood glue I used superglue to prevent future failures due to humidity.

7. Charango Soundboard Repair

Laws in South America prohibit the export of charangos made from armadillos. Therefore, it was quite extraordinary when an acquaintance from Ecuador had a charango with an armadillo body. The animal was properly captured in Ecuador and the instrument also made in Ecuador. Unfortunately, the instrument was damaged in storage.



Figure 25 – Ecuadorian charango with the body of an armadillo. Creating a level surface to mount the patch (top). Attachment of the patch (bottom left). Finished (bottom right).

The front of the charango had multiple stress fractures and a large hole below the bridge. The pieces were not available so I used wood leftover from building my guitar to patch the hole. The soundboard was attached to the armadillo shell with a thin piece lining the edge of the shell. This had partially ripped off where the hole is so I glued my own piece to create a level surface (Figure 25).

The fractures running lengthwise were glued and any indentations leveled by spreading a paste of fine wood particles and glue. Once the paste dried more sanding was needed to level the surface and then a coating of shellac was applied.

8. Violin Nut Repair

At the time of this repair I had been playing this violin for about 10 years. From the years of use the strings had created grooves in the nut and were now too close to the fingerboard (Figure 26).



Figure 26 - Before repairs. The nut has grooves from years of play.

Instead of replacing the piece of wood that had been indented, I chose to fill in the grooves. This was done by taking a fine powder of a hardwood, mixing this with glue and spreading it over the nut to fill in the grooves. Figure 27 shows the nut after it has been sanded.



Figure 27 - After repairs. The nut has been leveled.

9. Stereo Microphone Construction

Thanks to my former internship employer, Audio Engineering Associates, I obtained a few microphone capsules to take with me to Spain and South America. After learning the principles of playing the flamenco guitar I wanted a stereo microphone to record the guitar. I soldered two capsules to a $\frac{1}{4}$ " stereo audio cable assembly.

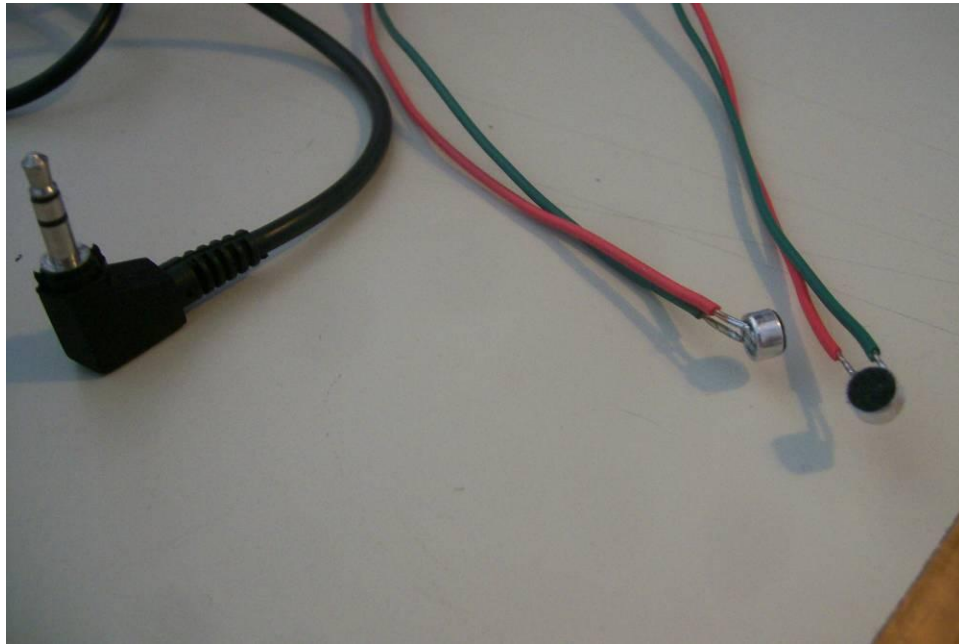


Figure 28 - Close-up of the capsules attached to a $\frac{1}{4}$ " stereo jack.

As a makeshift microphone stand I used a clothes hanger and recorded with an M-Audio portable recorder with a $\frac{1}{4}$ " stereo input (Figure 29).



Figure 29 - Stereo microphone mounted for flamenco guitar recordings.

10. Binaural Microphone Construction

A follow-up to the stereo microphone was creating a binaural microphone. The goal of this microphone was to do spatial recordings. For example, markets, concerts, and nature.

I hollowed out an old pair of headphones and inserted my microphone capsules in the cavity. When placed in the ears, as you would with regular headphones, this microphone picks up the spatial effects to be played back using headphones.

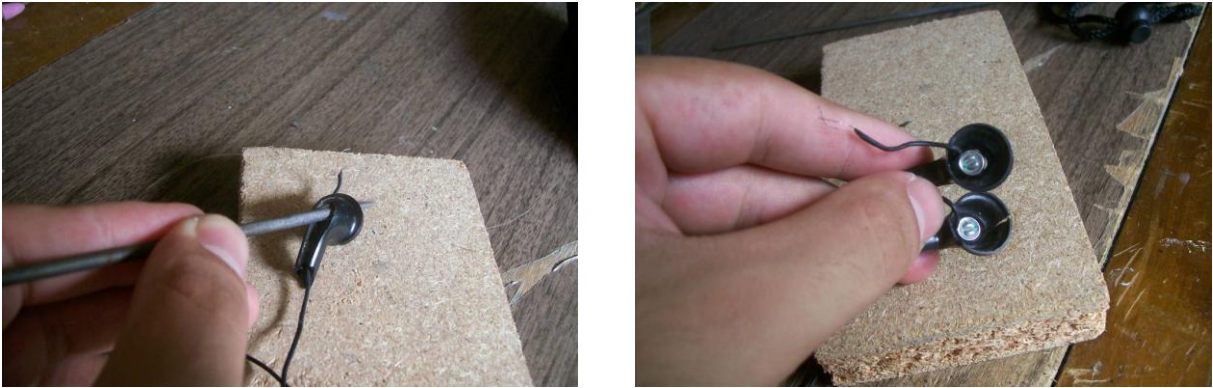


Figure 30 - Headphones hollowed out (left) to insert microphone capsules in the cavity (right).

Another function of this recording setup is the discreteness. You are able to make recordings of public spaces without drawing attention to one self.



Figure 31 - Binaural Microphone