There is something seductive about a field of lines. When they become comparatively close together, they simulate volume. When they move apart, they simulate a non-continuous surface. Contour lines have been used to break down volume into 2D space to simulate topography, to create the illusion of volume in etching, and to break down surfaces into ribs that can hold cladding.

Do the drawings above simulate a real event? Are they representational? They vacillate between suggesting volume and decomposing into lines. When learning the drawing techniques of the Renaissance, once might begin by performing an exercise of contour lines to articulate an object, noting the particular bumps and grooves. Advancing, however, one would draw only the shadows, using the fewest lines possible to indicate surface, texture, and volume.
I began to research ways of translating 2d information into 3d environments. I was attracted to digital rendering because it appears to use a similar strategy as the drawings: a field of lines disturbed to create the illusion of volume.

An unevenly textured surface can be digitally rendered in three ways: force shading, force perturbation, and displacement mapping.1 Force shading is a way of wallpapering an image onto a model. Force perturbation simulates surface texture without altering the model. Displacement mapping alters the model. Since it alters the model, the model must be composed of a fine mesh, so that local manipulation is possible at a sufficiently fine scale.

Using force perturbation, a bump map can be applied to a surface. To do this, a contour map is taken of a flat plane, and then the plane is applied to a volume. This allows a drawing to move immediately into a volumetric situation. The repercussions of the texture can be seen in section, and can be used toward future iterations of texture mapping.

This technique requires a parametrically controlled contour map, however, the textural qualities of the map are lost when the surface is applied to a volume.

Next I looked at models produced from CT scans, another method of transforming 2d image into a 3d volume. A CT scan captures thin sections of its subject.

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sections can be studied individually to find an embedded abnormality, or they can be reassembled with a digital printer to reconstruct a volume. In Figure 4, we see the striations caused by the tolerances of the tools, creating a texture slightly more rough than the original. The effect of the marks is reminiscent of the contour lines in the first drawings.

I moved on to find a project that specifically investigates the translation of 3d digital model to 3d physical model. This project was documented in *The End of our Meta-Mechanical Body*, a review of an undergraduate design studio at the Architectural Association in London. The student downloaded mesh models found online in the opensource libraries dedicated to gaming. He recombined two digital models in a collage technique and selected a composition from the volumes. He then sectioned the composition in various thicknesses to construct a physical model. The lateral section pieces are held rigid by toothed longitudinal elements. The process by which the student derived the necessary cross-contour is not shown.

The model articulates a way of developing form from something like contour drawings. In the first drawings, a few strategies are applied. First, there is a loose, fabric-like draping, somewhat similar to the bulbous sections shown in this project. Also, there are thin ridge-lines, like
a snag in a diaphonous fabric.

If a sectioning strategy were applied to the volume, the ridge-lines could represent the longitudinal framing. This does not resolve whether this snag is also articulated in the sections, but it might direct design. A disadvantage of the previous example lies in the fact that the lack of flexibility in the composition. Once the volumes were selected and sectioned, they may not be altered with the same fluidity as they were generated.

This strategy is less attractive because it lacks fluidity. A parametric definition could use a shape or a drawing to derive the final form. It could include the sectioning process as part of the definition. By proceeding in a parametrically controlled manner, the source could be adjusted without creating excessive trash in the model, and without committing to a particular iteration too early.

The attraction of sketching in Processing comes from the simulation of gesture. The drawings in Figure 7 use a simple set of operations where proximity and velocity drive the direction and density of tiny lines. The drawings imitate the fibrous growth of bones. Simultaneously, when drawing in ink it is effective to create graded tones by repeating pen strokes to suggest the light cast along a surface.

Using techniques of Renais-
sance drawing to produce buildable volumes might allow the gesture of the original sketch to find its way through construction logic in a recursive process.

The drawings simulate the folding and draping of fabric. Some marks represent engagement with structure: these appear as snags. Other marks cause the fabric to drape and react. The fabric reacts to varying degrees. The effects of a line on the field could be controlled by a range component that’s tied to a (perhaps cyclic) equation. There should be several kinds of range components, these will generate the texture.

Reflecting on these case studies, two potential strategies seem worth pursuit:

Strategy A: There should be three elements to the composition segment. The first is a direct, compositional line-drawing. The second is a field of lines. The third is a line-drawing for cross-structure. The field of lines responds to the line-drawing. By drawing lines, the field of lines is composed. Then, the field is applied to a volume, and the model is sectioned into ribs. The fine ridge lines are a way of breaking down the volume to create rigidity.

Strategy B: There is a volume with control points that can be manipulated and adjusted. Like the example in Figure 6, the volume is broken down into ribs.

Another concern: Are ribs the best way to do this? depending on the scale of the object, the ribs may need to be broken down into smaller segments. The advantage to using ribs is that they re-present the source drawing, and they can be cut of a stiff material to produce a structure that can receive cladding, and hold itself up.

As I proceeded, I developed control with Grasshopper by trying a variety of strategies. I arrived at a work flow that addresses various aspects of my primary investigation. Along the way, I followed several unsatisfactory lines of logic.
I began by creating a definition where I could draw in 2d plan and have the drawing effect a 3d form. The intention was that the line I am drawing with is intersected in the x-axis (but not the z-axis) with the field of lines. The intersections should become control points, which I can adjust by manipulating the line on its own.

I settled on intersecting the line of influence with vertical planes, which seem flat in plan. I didn’t get to converting the intersections to control points.

At this point, I reconsidered this strategy. The sacrifice to intersect with planes makes the sketch not represent the original idea. The control points here would adjust the planes rather than the lines. What I’m looking for is somewhere between a range of influence control and the ability to manipulate the z-axis.

I still need to intersect lines in the x-axis but not the z-axis and convert the intersections to control points. Then the lines of influence can be in line in the x-axis but lifted away from the field along the z-axis.

Here’s a diagram of the overall idea:
I continued by exploring the possibility of using the 2d sketch as source material, rather than as a model of an approach. The previous page uses the image mapper function in Grasshopper to translate the original sketch in a more direct way. Adapting a strategy covered in class, tiles rotate in relation to the brightness of the image. The brighter value causes more rotation. As an added step, I abstracted screenshots of the tiled image, producing another source that could be fed through the loop. This strategy felt tangential.

Regrouping, I made another attempt. This sketch is controlled by points distributed along the field of lines at the bottom in the x axis, and by sliders in the y and z axes. A selection of points were extracted and can be maneuvered individually. The surface is constructed using a Delauney mesh.

This sketch can then be baked, sectioned, and exported to the lasercutter.
However, as mentioned in the primary research, the compelling aspect of Processing to integrate the effects of gesture (rather than gesture itself) was not addressed by this method. I wanted to try a work flow that linked Processing and Grasshopper.

Using Processing, I simplified an existing sketch found on an open-source website, (http://www.openprocessing.org/visuals/?visualID=9651).

Red lines are lines that influence the field of black lines: they are drawn with the mouse. I can then export the image as a vector drawing to another program.

I exported the vectors to Rhino, and referenced them into a grasshopper definition.

I use the lines from the initial Processing sketch as the bottom edge of a plane to create a polygon.

Rotating the planes 90 degrees makes the flat sketch become volumetric. The planes where the sketch seemed to recede in space are now shorter.

Ceiling topography creates a lightweight hanging space that can be fabricated very simply because it need not support its own weight.
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I reviewed the model with my thesis advisors. One commented that it was too Cartesian: too much based on the Renaissance concept of slicing a volume to control something irregular. In addition, it felt too weightless and out of context.

Another opined that the best part of the model would be how it changed over time: the light filtering through the baffles at different times of day.

The comments can be addressed by altering the model either physically or digitally. The physical object can be adjusted by changing the spacing, the material, the relationship of the baffles with the wall and floor, the relationship with each baffle to the next.

Or, the digital model can be made more sophisticated by controlling opacity and density according to programmatic needs. However, this would not address the sense of anti-gravity produced by the digital model.

Gravity might be addressed by using a different material, by changing the shape of the material to represent gravity, or by integrating Processing in the initial construction to make a sketch more responsive to a simulated gravity.

I am excited to push this model further by exploring its construction logic. As it stands, to make a 1:1 scale model would entail hours of lasercutting. The smooth edged forms would need to be tiled into segments that fit on the lasercutter bed, and then carefully reassembled. I am planning on making a model over the summer using glassine, an interleaving used in printmaking to protect prints from decay and fading.

With this in mind, I begin to reconsider the nature of the project. The cuts in the model I made are so regular that they don’t really need to be mapped on the computer, perhaps they could be assembled according to logic that is bottom-up. In other words, each piece could relate to the next in a more straightforward way.

Returning to some of the earlier sketches, it could be that string lines are drawn in space indicating the ridges and valleys of the intended form. Then, the glassine is cut to fit these lines. The digital model would then offer an indication of the form, but the actual form could be less rigid, and more hand-manufactured.

An important aspect of manufacturing, ignored so far in this study, is spacing. The relationship of spacing and depth of the form in the z-axis will construct the spatial experience of light. The edge condition will make the form relate to the human scale. However, the conditions that derive this spacing and human relationship need to be defined by a built situation.