Informal Notes on the Geometry and Kinematics of Guided-Rod Sharpening Systems

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8:17am
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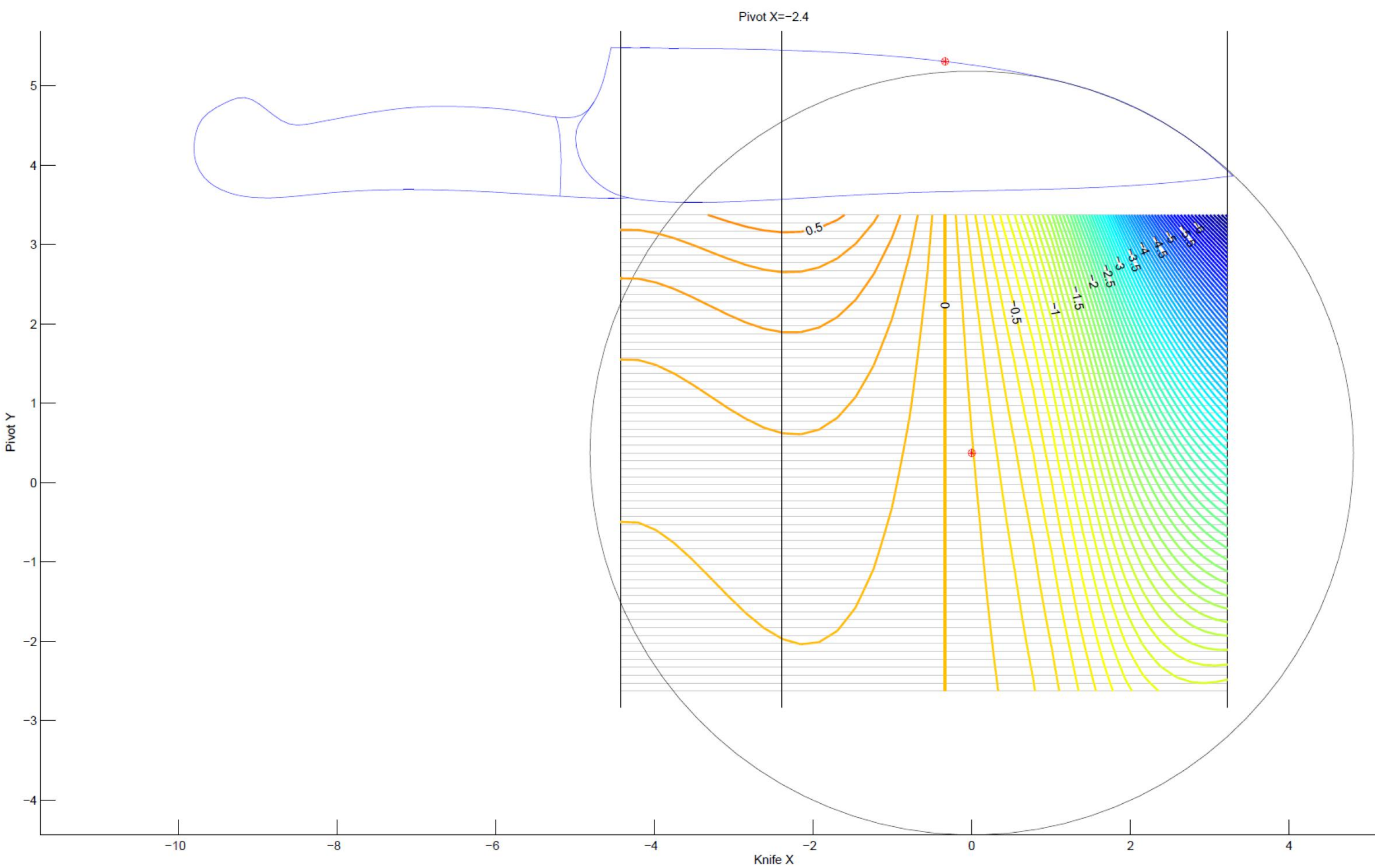

Figure A.2: Contour Plot of Sharpening Angles. The red point on the knife edge represents our calibration point (set to 15°in this example). The vertical black line at $x = 2.4$ represents the x-coordinate of the spherical joint of the WEPS-Gen2. Each horizontal gray line represents a choice of y-coordinate for the spherical pivot. In addition, each point on a gray line corresponds to a point on the knife edge (namely, the point on the knife directly above on the page). When a gray line crosses a contour line, the sharpening angle has changed by 0.1°per side.

Let us explain all the different parts of this picture. First of all, you can see the silhouette of the chefs knife. The red point on the knife edge is our calibration point: the sharpening angle at this point will always be exactly 15 degrees per side. Suppose we want to try placing our spherical joint at coordinates $x = -2.4$ and $y = -1$. So, we first fix $x = -2.4$ which is represented by the black vertical line in the middle. Next we move along this vertical line until we get to $y = -1$. This is how we set the (x, y) position of the spherical joint of the WEPS-Gen2.

But how do we read off the sharpening angle? This is where the contour map comes in. Each of the horizontal gray lines represents a foot-path through our "landscape." From the point $(x = -2.4, y = -1)$ in the figure, we can travel horizontally (left or right) along one of these gray lines. Each time we cross a contour, our sharpening angle has changed by $0.1°$ per side. As we walk along this gray line, our "altitude" represents the sharpening angle for the point on the knife with the same x-coordinate (on the page, draw a vertical line until it touches the knife edge).

So in our example above, we see lots of widely spaced contours near the heel of the knife. So with our pivot at $(x = -2.4, y = -1)$, the sharpening angle near the heel is almost constant. However near the tip of the knife, the contours get very close together! So the sharpening angle changes a lot here. So how much does the sharpening angle vary? We can find out by counting how many contours we cross as we walk along the gray line. Each time we cross a contour line, our sharpening angle (ie: "altitude") has changed by $0.1°$ per side.

Additional Notes

The landscape we plotted has "sea level" set to at 15 degrees per side. So the contour labeled "0" means no deviation from our target of 15° per side. The contours labeled "0.5" means we have increased the sharpening angle by 0.5°per side, so we would be at $15 + 0.5 = 15.5°$per side. Similarly for the "-0.5" contour, and so on.

Please ignore the colors in the contour plot. I'm thinking about what a good color scheme should be and learning how to set the colors in Matlab. But for now, I'm just using Matlab's default colors, which do not mean anything in this plot. I kept the colors because they are still useful for seeing the direction of contours when they get very dense.

A.3.2 Animation

So far, we have a "landscape" and the horizontal gray lines are our "foot paths." And we can walk along the foot-paths and see how many contours we cross to see how the sharpening angle varies. But this landscape is only for a specific value of x, our choice of x-coordinate for the spherical joint! We want to try many different x-coordinates for the spherical joint.

This is where we use animation as a visualization technique. We can make many landscapes:

one for each position of x-coordinate for the spherical joint. Each animated frame has a vertical black line (the one that is moving) that represents the x-coordinate of the spherical pivot.

A.3.3 Example

Let us work through a specific example. Consider the red dot marked in the landscape of Figure A.2. Suppose we want to place our spherical joint there. We go to the frame of the animation where the vertical black line goes through that point. Here is that frame. (See Figure A.3.)

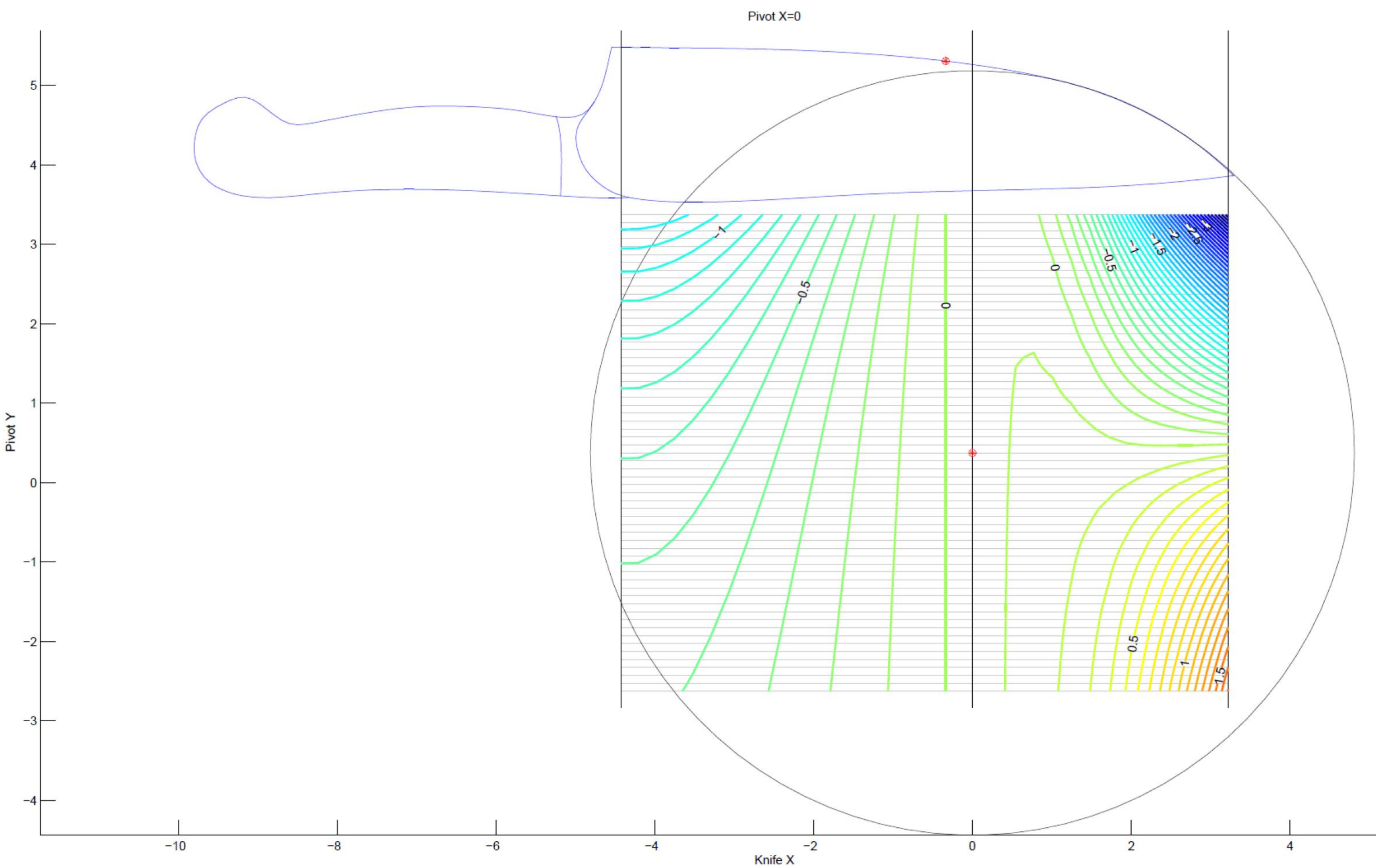

Figure A.3: Example Contour Plot of Sharpening Angles. To place the spherical joint at the red dot below the knife, we first go to the animated frame where the moving vertical like goes through the red dot. To find the variation in sharpening angle, we travel left and right on the gray line that goes through the red dot. Each contour line represents a change in sharpening angle of 0.1°per side.

Next, the red point is on a horizontal gray line. We can walk left-and-right along the gray line.

Each time we cross a contour, our sharpening angle has changed by 0.1° per side.

In this example, we have placed the spherical joint at the position of the red dot. When we do this, the sharpening angle near the tip of the knife is almost constant. That is, as we walk to the right along the gray line, we cross very few contour lines. We cross one, maybe two lines, which means a change of 0.1° (maybe 0.2°) per side. However, near the heel of the knife on the left, we cross many contour lines. From the plot, we can see that the sharpening angle decreases as we cross 7 contours. So our sharpening angle decreases by 0.7° per side.

Finally, notice the vertical contour below the calibration point. Of course this must be there! This is because we are setting the WEPS-Gen2 to sharpen at 15° per side at the calibration point, for every choice of (x,y) position of the spherical joint. So we will always have a vertical contour line below the calibration point, and it will have an "altitude" of zero degrees per side. That means, zero degrees per side deviation from our target angle (which is 15° per side).

So what are we looking for? We want to search all the frames for a horizontal gray line which crosses as few contours as possible, and which is also the closest to"sea level" as possible. Once we find such a gray line, we find its intersection with the moving vertical black line. Our optimal pivot placement is at intersection of this horizontal gray line and the vertical black line.

A.4 Example Visualizations for Optimal Pivot Placement of the WEPS-Gen2

If you understood all that, congrats! Sorry if it is so complicated. I'm unsatisfied with this visualization, but it is the best I can come up with for now. Here are the animated videos of the contours. The red points marked in the contour plots are the same pivot locations as used in Section 6.7 and correspond to Figure 6.15, Figure 6.17, and Figure 6.19.

A.4.1 A Chefs Knife on the WEPS-Gen2

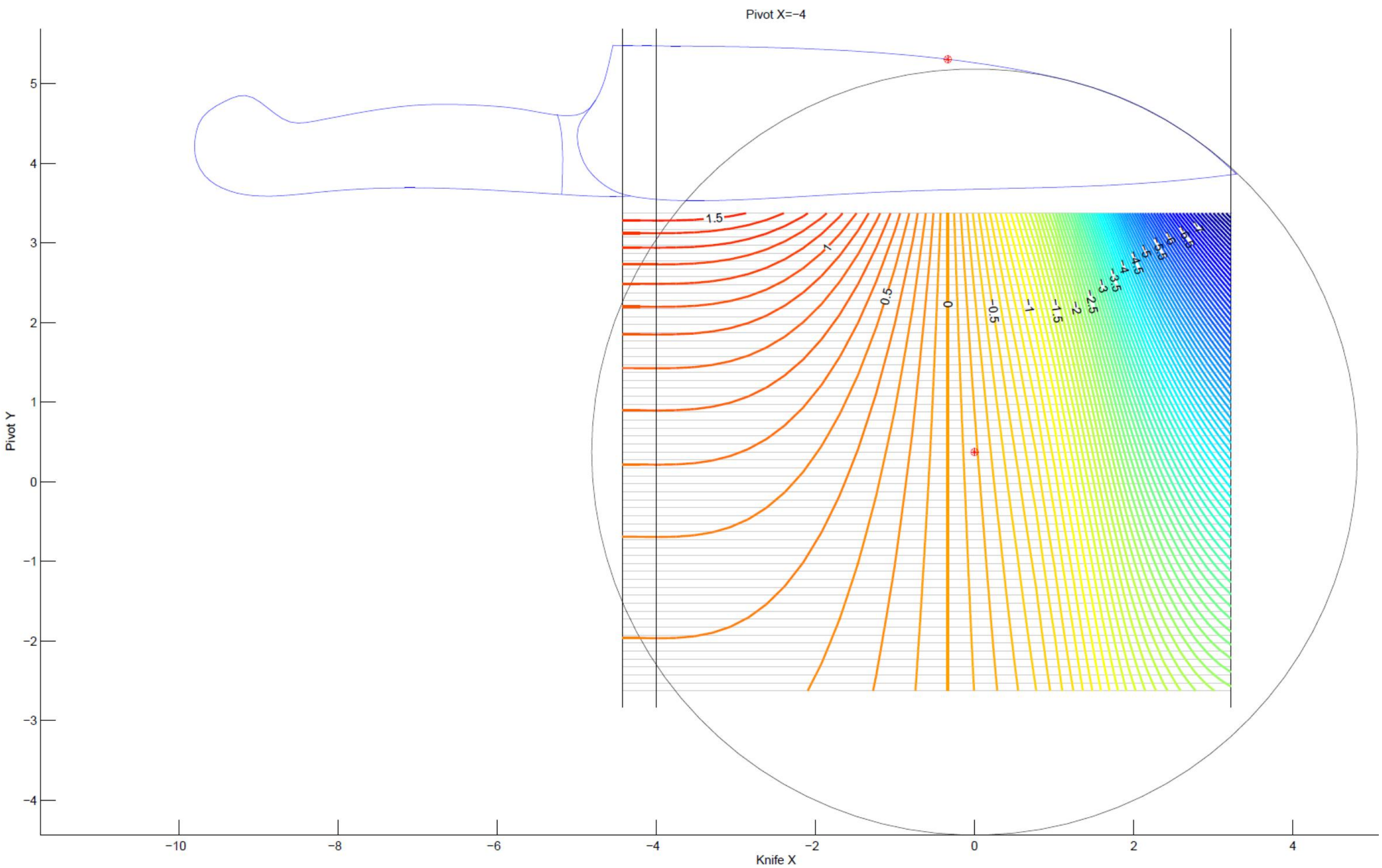

Figure A.4: Visualization for a Chefs Knife on the WEPS-Gen2. Coordinates are in inches. Target sharpening angle = 15°per side at the calibration point. Contour lines every 0.1°per side.