Score Sheet. 600.445 Homework #4 – Fall 2003
Name:_________________; Email: _______________

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<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>1. Design approach</td>
<td>40</td>
</tr>
<tr>
<td>2. Mathematical analysis</td>
<td>40</td>
</tr>
<tr>
<td>3. Discussion</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>110</strong></td>
</tr>
</tbody>
</table>

I worked **alone** on this assignment and followed all other guidelines:

______________________________  __________________________
signature                  date
General Notes and Instructions

1. I would really appreciate typed, double spaced and READABLE output that is firmly attached together. Sketches can of course be hand drawn. I am not looking for beauty, just legibility and room to mark them up. Generous margins are also nice.

2. Put your **name and email address** on each sheet and number the sheets.

3. Attach the grade sheet as the first sheet and attach all sheets together.

4. You must include a self-addressed, seal-able 8 ½ x 11 inch envelope if you expect to the homework to be returned (per JHU’s interpretation of FERPA).

5. You should work **alone** on this exercise.

6. The problem is open book, notes, library, etc. But you should cite any source materials you use or consult.

7. I do **not** expect truly expert answers at this point, nor am I expecting a great deal of clinical expertise beyond that included in the referenced book chapters. The main purpose of this exercise is to get you thinking analytically about the relationship between systems, application needs, and technology.

8. This assignment is due at the start of class on 10/3/03. I urge you to start earlier.
Assignment 4

• Consider the CT scenario of Assignment 1. I.e., the problem of placing needles into the spine or perispinal region onto targets whose positions have been identified in CT images.

• Assume that the following technologies are available
  – Lots of computing power
  – Human-machine interfaces & display devices
  – The ability to instruct the CT scanner to move the scanner table & gantry, acquire images, and transfer the images to a control computer.
  – Optical tracking of individual LED or retro-reflective markers relative to one or more 3D optical tracking sensor units.
  – The ability to construct customized robotic devices, robotic end-effectors, simple hand tools, needle guides, etc.

• Your problem is to design a system for accurately placing needles onto targets identified in CT images, using what you have learned.

• Note that the problem is continued for Assignment 4
Design and Analysis

• Describe a design for accomplishing this task. This design should include
  – A block diagram & descriptions and/or sketches of key components
  – Descriptions of information flow between components
  – Analysis of key coordinate system relationships
  – Outlines of system calibration & setup procedures
  – Outlines of system and application workflow
  – Sufficient mathematical and algorithmic description to clearly indicate how each step is to be accomplished.

• You are welcome to follow the design you used in Assignment 1 or to present a new design, but you should provide more detail.
  – For example, if you are placing optical markers on a surgical instrument, you should describe (at least approximately) where you will put them & how you will perform the necessary calibrations. A sketch or two is likely to be very important here.
  – Similarly, if you are relying on a robot, you need to describe it at least approximately, explain how it will be mounted, how it will be registered to the patient and/or CT space, how it will be calibrated, etc.
  – Similarly, you should explain what the human-machine interfaces should show, perhaps giving a sketch or two of any computer display screens, etc.
Discussion

• Discuss your design (qualitatively) from several points of view:
  – Overall system functionality
  – Flexibility/versatility (ease of adapting to other uses)
  – Ease-of-use
  – Setup time
  – Cost
  – Development time & how you would go about developing the system

• Again, I am not looking for a “book”. A short paragraph on each of these elements would be just fine
Problem Scenario: Percutaneous Spinal Nerve Blocks

Consider the problem of percutaneous injections into spine nerve roots, as discussed in class.

- Typically done by interventional radiologists
- Requires accurate placement of a thin needle (typically 22 gauge) near a nerve root, followed by injection
- Typically performed freehand under x-ray or CT guidance
- Typical procedure time is about 30 minutes
- High volumes

NOTE: Thanks to Dr. Gabor Fichtinger for providing background material on this problem
Why Spine? Why pain management?

- In US alone 70% of population affected in lifetime
- Single most expensive disease
- Pain management: alleviate pain caused by stressed/pressed/pinched spinal nerve by suppressing sensory input at nerve root
- Numb with lidocaine/novocaine etc.
Current standard 1: CT guidance
Affix IZI Biopsy Strip  Pick Entry and Target
Current workflow for CT-guided procedure

1. Put patient in prone to scanner
2. Palpate vertebra
3. Affix IZI Biopsy Strip fiducials
4. Take thin volume scan
5. Select slice of interest
6. Pick target and entry
7. Determine angle and depth
8. Pull out patient to outer laser plane
9. Identify entry on skin
10. Touch needle to entry point
11. Enter needle manually – 22G beveled
12. Maintain insertion angle by sight
13. Keep needle in laser plane
14. Judge current insertion depth by feeling
15. **Insert contrast (optional)**
16. Push patient back to scan plane
17. Take confirmation CT
18. Pull out patient
19. Inject therapeutic agent
The challenge

- Transfer entry, angle and depth over patient
- Control all 3-DOF simultaneously during insertion