Score Sheet. 600.445 Homework #1 – Fall 2003

Name:________________________; Email: __________________

1. (30 points)
   A. (15 points) _______
   B. (15 points) _______

2. (50 points)
   A. (15 points) _______
   B. (15 points) _______
   C. (10 points) _______

3. (20 points)
   A. (15 points) _______
   B. (5 points) _______

   (100 points) _______

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

________________________
signature                    date
600.445 Homework # 1 - Fall 2003
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.
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 gage) 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/pressured/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
Current standard 2: C-arm Fluoroscopy

Courtesy of Siemens
Current workflow for Fluoro-guided procedure

1. Put patient in prone on table
2. Palpate vertebra
3. Set C-arm in anticipated needle direction
4. Turn on beam
5. Adjust C-arm angle to optimal
6. Reach into beam with needle
7. Touch entry with needle tip
8. Keep needle perpendicular to beam
9. Optimize entry location
10. Fulcrum with needle till barrel-view
11. Turn off the beam
12. Rotate C-arm by 90 degrees
13. Turn beam on, keep beam on
15. Monitor insertion depth/deflection in image
16. Stop needle at target position
17. Insert contrast (optional)
18. Take confirmation C-arm image
19. Inject therapeutic agent
Question 1 – Analysis of existing procedure

A. (15 points) Develop an outline for evaluating this procedure, including such factors as “cost”, “safety”, “effectiveness of pain relief”, “accuracy”, “time”, etc. For each such criterion, include:

- **Short** definition or explanation of the criterion
- **Short** discussion of how that criterion should be assessed (e.g., units of measure, means of gathering information)
- **Short** discussion of how important each criterion is to each relevant group affected (patient, surgeon, hospital administrator, insurance company, employer, etc.)

B. (15 points) Use this outline to evaluate the existing manual methods using these criteria.
Question 2 – Identifying alternatives

A. (15 points) Sketch an alternative approach using computer assistance to enhance this procedure. Do not write a book. I am looking for 1-2 pages maximum, possibly with a sketch or two.

B. (15 points) Sketch a second, distinct approach using computer assistance, with the same sort of information and discussion included in Part 2.A.

C. (20 points) Develop an outline evaluating the two approaches using the criteria developed in Question 1. Your analysis should compare your approaches to each other and to existing manual practice.
Question 3 – Fleshing out the preferred embodiment

A. (15 points) Based upon your analysis in Question 2, select one of your proposed system solutions for further design evaluation. For this design, provide an additional 2-3 pages total (discussion + sketches) outlining the technical approach. Your discussion should clearly define

- Preoperative, intraoperative, and postoperative information needed.
- How this information will be obtained.
- Key coordinate systems associated with various aspects of the system and the relationships between them.
- Important components and human interfaces.
- What components need to be developed.
- What components (if any) need to be “invented”

B. (5 points) Outline the steps you would need to take to develop this system and present a rough schedule and manpower/cost estimate. Provide a sentence or two justification for your estimates.
Important NOTE

• There is no single “right” answer to these questions, and I am well aware that people may not have either the experience or the knowledge to make highly credible estimates of things like schedules and costs. The purpose of the exercise is to get you to think.

• In grading the answers, we will be looking more at your reasoning and your approach to the problem than at the specific “correctness” of any technical solutions you come up with.

• At the same time, do try to keep sight of the specific goals of the application, and don’t simply resort to science fiction. An answer proposing well trained termites is not likely to score very well.