Homework problem 1 (to be completed and turned in prior to the class on October 1, 2003)

N.B.: Depending on your interests you can alternatively work on either problem 1a (geological core logging application) or problem 1b (remote sensing application). You do not have to solve both problems.

The total number of points you can obtain for solving this problem set is 10, and this will count towards the total of 100 points (i.e., 55 for homework problems, 15 for quizzes and 35 for semester project) that you can earn as part of this class until the end of the semester.

Problem 1a:

(i) You are responsible for core logging operations in the Eldorado Gold Mine*. Among other things, this entails the photographic documentation and visual logging (including notekeeping) of roughly 50 m of 5 cm diameter cores that are brought into the lab during the course of a week. After a few months on the job, you realize that you can significantly improve the whole process of core characterization and image archival by switching from good old-fashioned photography to a fully digital core imaging and archival system.

Now all you need to do is convince the mine administration that this is the way to go. Write a memo to management outlining the idea and providing good arguments to back up your suggestion (keep it short, not more than a page or two, and convincing - after all, they’re busy enough keeping track of finances with up-and-down gold prices, so they may not exactly have waited for deep insights from the core-logging shed).

(ii) Based on your compelling argumentation, the mine management has decided to give your idea a try. It turns out that the human resources office had to get rid of an older PC (at least it’s still young enough to feature a Pentium III*, and a monitor came with it), so on top of that you’re granted 6k$ to buy whatever else you need to achieve your goal.

Assemble an image-processing system (including some means of storing data) and explain your choice of components. To get an idea of what’s available on the market, you turn to the web, in particular the following suppliers/manufacturers:

http://www.diaginc.com/
(iii) The set-up has been fully assembled (you’ve decided to buy a colour video camera and a frame grabber) and you’re all ready to go and start recording those core images, when – much to your dismay – you discover that the image quality is poor, with horizontal white streaks and flashes showing up in your images (which also appear somewhat grainy). Pondering this problem (the demo images that had been provided through the web looked just fine and not at all like this here …) you stare up into the fluorescent lights, your only source of illumination in the dimly lit core shed (this started out as a storage hut, so there are no windows either). Suddenly, you get an idea of how to solve this problem. What was the problem and how do you solve it? Write another short memo to management telling them why illumination is so important and why they should spend another 1k$ to get a proper light source that also allows for semi-quantitative studies of core colour.

(iv) The whole image-processing operation has been a full success and everybody involved is glad to have taken this step. Talking to one of the old-timers at the mine you learned that you can actually see specks of gold in the core images if only you could resolve sufficient detail (no problem: to get 100 micrometers resolution for each of your images of a 0.1m long core section you just need to have the proper camera). Also, after comparing core segments and the lab results, you were able to establish that if carefully monitored and compared against soil colour tables, the colour of the core is actually a very good indicator of the gold content. Armed with this information, you’re able to convince the management that they should invest another 10k$ into your lab to upgrade the camera system. What type of camera do you buy now and why (look at web site of http://www.cri-inc.com/instruments/products/spectral.shtml is this something that might be of interest?)? How would you ensure that the semi-quantitative colour information you derive can be compared between any two given cores taken possibly as much as several months apart?

(v) Looking back on a 2-year-career in the core logging shed, how much image data did you generate during that period?

(vi) The management insists on maintaining some form of record or sample of all the cores for at least another 50 years (whatever is to be kept will be locked away in a safe,
climatized spot for the entire period). What do you think is worth keeping? The images (as print-outs or digitally?), the samples?

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* Mention of brand names or registered trademarks does not constitute any form of endorsement by the instructor (nor his employer) and is for instructional purposes only
Problem 1b:

(i) You're with a small consulting company that has gotten a contract with the Fairbanks North Star Borough to assess the extent of "Urban Sprawl", i.e., the increase in private and commercial land use resulting in an increasing ratio between developed vs. undeveloped landscape, in the wider Fairbanks area during the past 30 years. The Daily News Miner has learnt of this and is interested in covering your project in a feature article. In order to properly refer to your work, the reporter asks you for a short write-up, outlining your strategy to detect changes in the land-use status (i.e. undeveloped vs. developed) by applying image-processing techniques to remote-sensing data. Write such a summary and discuss in particular what type of data you hope to be using for this task (e.g., panchromatic, multispectral, aerial photosurveys or satellite data etc.) and how you would address the problem of determining changes by employing automated or semi-automated techniques. Since this is for a general-readership newspaper article you don't have to worry too much about identifying individual data sets or outlining the technical detail of the methods employed, rather you should provide a good overview into how such a problem could be tackled.

(ii) While the entire area that is to be studied amounts to a rectangle of 200 x 400 km², through further research you have been able to establish that you only need to obtain imagery or data for a total area of 25,000 km², distributed fairly evenly in smaller patches or tracts throughout the total area. For the "status quo" data showing the present state of development you are left with the choice of either utilizing satellite data or aerial photography (for which you would have to schedule special flights). Present arguments (in writing) for choosing either one of the two or a combination of both to solve this task (taking into account both issues of resolution, coverage etc. as well as financial issues; for the satellite data assume that it costs you $5000 per scene and that full coverage of the entire study area requires the purchase of 10 scenes; you can learn more about such aspects at the following two web sites for, e.g., Landsat and similar data: http://edc.usgs.gov/products/satellite.html, http://edcsns17.cr.usgs.gov/EarthExplorer/; for aerial photography assume that including all associated costs, an hour of flight time amounts to roughly $500 and yields coverage of 500 km²).

(iii) The search for a good source of data from the late 1960's and early 1970's takes you to the GI Map Office at UAF (http://www.gi.alaska.edu/services/MapOffice/index.html). The Map Office has just the right kind of data in stock for your purpose and you obtain a sample scene of the Yukon river and surrounding woodland near Stevens Village to test your strategy (the scene is shown in the pdf file below). What type of data is this likely to
be and how do you explain the colours shown in the image (see also Table 1 below for a further hint). Also, can you provide an explanation of why so much of the scene shows up in red and why the Yukon River appears so prominently blue? Why are the sloughs and ponds showing up black?

(iv) After you've purchased a whole set of photographic hard copies of the older remote-sensing data such as the scene shown below, you somehow have to digitize these data. Discuss two different options for accomplishing this task, taking into account speed, cost and results (colour, resolution).

(v) After successful completion of your project, covering a total of 25,000 km$^2$ of surface area for two different years at an effective spatial resolution of 10 m, how much data have you generated (in MBytes)? The North Star Borough wants to make sure that a data base exists to revisit the issue of urban sprawl 50 years from now and asks you to derive a data archival concept that ensures this. What would you suggest (data storage media, strategy etc.)? Suppose somebody filed away both photographs and storage media in a spot that was so safe that only after 50 years a public employee would stumble across the material again. What would be the relative merits or disadvantages of photographic prints or data storage media in such a scenario?
Figure 1: Remote sensing scene of Yukon River and Stevens Village (source: GI Map Office).

Table 1: Colour assignments for different sensor spectral bands (Schowengerdt, 1997).

<table>
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<th>display color</th>
<th>sensor spectral band</th>
<th>TrueColor (TC)</th>
<th>Color IR (CIR)</th>
<th>False Color (FC)</th>
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