Sample Question Paper 1 -

(based on MM61513 Autumn 2012-13)

Question 1:

In the year 2050 AD exists a technologically advance world with lots of life changing inventions. The field of medical imaging has advanced manifold and rapid screening modalities has improved quality of healthcare service. It is now possible to walk past a magic mirror which indicates early stages of tissue abnormalities within your body, thus making healthcare personalized, affordable and accessible. However, there is a critical problem which has not yet been solved. It is not yet possible to reliably detect reappearance of carcinoma (cancer) in previously cured areas. Professor Katsushi's research in quantum electrodynamics has been able to solve another critical limitation of our currently used theoretical physics model facilitating interaction with parallel universe. With this he has travelled to a parallel universe through a time-dimension worm hole and has visited Earth 3050 AD. There he had met Professor Ikeuchi, a fellow physicist, who had invented a wonderful device to sense electromagnetic (EM) phase changes at microscopic levels. Professor Katsushi and Professor Ikeuchi had collaborated together to leverage this technique to sense EM phase changes in biological structures, towards achieving a solution to the problem of reliably detecting reappearance of carcinoma (cancer) in previously cured areas. Aimed with this invention, they decided to pass on the technology to a previous era when advancement in medical imaging technology had begun. Transcending through the worm-hole, Professor Katsushi and Professor Ikeuchi have travelled to Earth 2012 and landed down at our wonderful campus of IIT Kharagpur at 8:30 PM local time. Incidentally, at the same time you had decided to take a brisk walk along PAN loop to freshen up from the hung up tiredness of writing your semester examinations. Totally new to an alien territory, Professors Katsushi and Ikeuchi spot you and approach you to be acquainted with our Earth 2012 and its social dictates. The scholarly eyed you would eventually listen to their motive of coming to our time, and having known that you specialize in Medical Imaging and Informatics, they feel relieved and would like to share their invention idea with you. They tell you about the experiments they had conducted and are currently facing problem with their limited knowledge and lack of experience of working with imaging. Here are the few problems they require your help in sorting out.

They have recorded a few samples of EM phase change data and have brought that along. One of the bmp files [data.bmp] is readings of the sensor from a phantom experiment. The other file [ideal.bmp] is set of expected readings. Since the data.bmp has noisy readings, before being included in real clinical workflow, they expect some way to filter out the noise in data while preserving the structures. They provide you with a critical information on nature of their observations. The dark areas in data.bmp constitutes the background while the bright area constitutes the readings. Further the noise is on account of dark current in the sensor circuitry and follows the $f_1(\cdot)$ distribution modelled as $f_1(x\,|\,k_1)=k_1^{\,x}e^{-k_1}/x!$ while the data is expected to follow the $f_2(\cdot)$ distribution modelled as $f_2(x\,|\,k_2,k_3)=e^{-(x-k_2)^2/k_3}/\sqrt{2\pi k_3}$.

T Suggest a method to process data.bmp such that the processed result (processed1.bmp) matches ideal.bmp as close as possible. With his limited knowledge of psychovisual perception, Professor Ikeuchi had suggested that instead of using the age old mean-square-error (mse) as a measure, if we can use one of the measures developed in 2008 which is modelled as $J_1(F,G)=(2\mu_F\mu_G+c_1)(2\sigma_{F,G}+c_2)/(\mu_F^2+\mu_G^2+c_1)(\sigma_F^2+\sigma_G^2+c_2)$ where $c_1=\zeta_1L^2, c_2=\zeta_2L^2$ and $\zeta_1=0.01$, $\zeta_2=0.03$. F and G are the test and reference images. μ_F is the mean intensity of F, and σ_F is the variance of its intensity. $\sigma_{F,G}$ is the covariance of intensity change in F and G. Here L is the dynamic range of the measured data. [10 Marks]

P Write down a modular implementation of the suggested algorithm. [5 Marks]

P Plot down response of the cost function and justify the rationale of choosing the perfect configuration of your processing method through minimal plots and illustrations. [8 Marks]

Wizard Identify names of distribution models $f_1(\cdot)$ and $f_2(\cdot)$ as used on Earth 2012. [2 Marks]

Question 2:

Having solved this problem using Professor Ikeuchi's suggestion, Professor Katsushi suddenly realized that there is another impending problem related to displaying this image. The display device he uses has a screen resolution of 400×300. Unfortunately, the graphics driving hardware on his display device does not support dynamic rescaling. Thus he would like you to rescale processed1.bmp to best fit the image to his device without cropping its sides.

T Compute the best fit scaling factor as a fraction. Briefly state the process. [10 Marks]
P Write down the modular implementation of your suggested algorithm. [5 Marks]
P Plot the cost associated with information loss due to rescaling. [5 Marks]
Wizard Can you consider Professor Ikeuchi's suggestion while computing the costs and how does it vary from your cost model, if any variation exists? Provide illustrations. [5 Marks]

Question 3:

Professor Katsushi is further demanding since he would like to have a clear view of the re-infected area displayed in white against a complete black background.

T How would you proceed to accomplish this demand from Professor Katsushi. Remember that using their physics models would provide you with the extra edge over others. [10 Marks]
P Write down a modular implementation with artefact correction available. [15 Marks]

Question 4:

Despite having solved such complicated problems, Professor Ikeuchi is not happy since being an experimental physicist, he would like to have some measurements of the abnormality.

T Can you compute the area, perimeter, compactness of the lesion. [10 Marks]
P Write a modular implementation of the above. [10 Marks]
Wizard Can you plot the lesion boundary on data.bmp? If so, create bound.bmp. [5 Marks]