SGN-13006 Introduction to Pattern Recognition and Machine Learning
Laboratory of Signal Processing, Tampere University of Technology
Exercise 3
*Visual classification (CIFAR-10 dataset)*

Be prepared for the exercise sessions. You may ask TA questions regarding your solutions, but don't expect them to show you how to start from the scratch. Before the end of the session, demonstrate your solution to TA to receive exercise points.

1. **CIFAR-10 – Bayesian classifier** (50 points)

   We continue with the CIFAR-10 dataset and we will adopt Bayesian classifier approach this time.

   First we need to select suitable features. Let's use the average color of each image as their imagery feature. Instead of the $\vec{x} = 32 \times 32 \times 3 = 3072$ length pixel vector for each image, you need to convert them to $\vec{f} = (m_R, m_G, m_B)$ values where $m_R$ is the mean value of the red channel in the image, $m_G$ green and $m_B$ blue, i.e. every image is represented with three values.

   Let's assume that channels are independent and normal distributed, i.e. Bayesian probability can be computed from

   $$P(class_1|\vec{f}) = \frac{P(\vec{f}|class_1)P(class_1)}{P(\vec{f}|class_1)P(class_1) + P(\vec{f}|class_2)P(class_2) + \dots} \ .$$

   Note that you may omit the demoninator parts since its same for all classes. Now,

   $$P(\vec{f}|class_1)P(class_1) = \mathcal{N}(m_R; \mu_{R,c_1}, \sigma_{R,c_1})\mathcal{N}(m_G; \mu_{G,c_1}, \sigma_{G,c_1})\mathcal{N}(m_B; \mu_{B,c_1}, \sigma_{B,c_1})P(c_1)$$

   where $\mu$ and $\sigma$ are the mean and variance of each class and for each feature.

   Write a function *f=cifar_10_features(x)* that forms the mean color feature of x. Write another function *[mu,sigma,p]=cifar_10_bayes_learn(F,labels)* that computes the normal distribution parameters for the samples in F (one line per sample) and respective labels in labels. Note that the size of mu, sigma and p (prior) must be $number of classes \times 3$.

   Finally write function *c=cifar_10_bayes_classify(f,mu,sigma,p)* that returns the Bayesian optimal class c for the sample f.

   Run your classifier for all CIFAR-10 test samples and report the accuracy (write another script for this).

2. **CIFAR-10 – More details** (10 points)

   Compute confusion matrix for the outputs of your Bayesian classifier and then plot normal distributions of two classes which almost never mix and two classes that often mix. What classes are classified best?

   *Hints:* mean(), std(), normpdf()