Machine learning - oral exam

Topics: The following list helps to identify important definitions and methods and covers the topics presented in the machine learning course.

A topic is selected/drawn corresponding to the topics in **bold**.

General keywords: Features, multivariate data, feature space, supervised vs. unsupervised, parametric vs. non-parametric

1. **Bayes decision theory**: A priori probability, class conditional probability density function, posterior probability, decision rules, boundaries and regions, minimization of error probability, loss function, discriminant functions
2. **Multivariate normal density:** Parametric density function, mean vector, covariance matrix, interpretations of the covariance matrix, Mahalanobis distance, hyper ellipsoid contours, probabilistic vs. distance based classification, normal density discriminant functions (3 cases)
3. **Non-parametric density estimation:** Histograms, volume based probability estimation, how volume and number of samples affect probability estimates, Parzen windows, window functions, k-nearest neighbor algorithm, distance measures
4. **Generalized discriminant functions and SVM:** Design of decision boundaries, linear discriminant function (weight vector, bias), generalized linear discriminant functions (homogenous form + feature transformation), hyperplane parameter estimation (sample normalization, gradient descent, criterion functions (Perceptron)), generalized discriminant functions vs. SVM, SVM kernel functions
5. **Unsupervised learning - Gaussian mixture models:** Gaussian mixture models (mixture density, Gaussian component densities and mixture components), maximum likelihood estimation, log likelihood function, expectation maximization for parameter estimation, component number selection
6. **Unsupervised learning – clustering**: Sample similarity/ distance clustering, c-means clustering algorithm, fuzzy c-means clustering, threshold distance vs. criterion functions, distance metrics, feature normalization, hierarchical clustering (dendrogram, similarity measures, natural clusters)
7. **Decision trees:** Decision trees classification structure, links and nodes, train binary decision trees (node data splits, feature selection, node impurity criterion functions, leaf node classification), random forest

8. **Feature selection and dimensionality reduction:** Principal component analysis, heuristic feature selection, forward selection, backward elimination, classification performance metrics
9. **Basic neural networks:** Artificial neurons, net activation (weights and bias), activation functions (non-linear), 3 layer neural network architecture, fully connected, shallow vs. deep networks, training of neural networks (loss functions, stochastic gradient descend optimization, backpropagation, and parameter estimation), number of units vs. computational capacity
10. **Convolutional neural networks:** Convolutional layer, filter weights, relu activation layer, pooling layer, loss functions, deep CNN architectures, feature extraction + hierarchical features, hyperparameters, generalization strategies (data augmentation, dropout, transfer learning), vanishing gradients
11. **Generative networks:** Autoencoder, Variational Autoencoder (mean, variance and Gaussian noise, Kullback-Leibler divergence), Generative Adversarial Network (Generator and discriminator, training loop, loss function), Adversarial Autoencoder (adversarial network on latent space, reconstruction loss, adversarial loss), latent space (normal distributed), pros and cons,