课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	**课程名称 Course Title**	**机器学习（H） Machine Learning (H)**
2.	**授课院系 Originating Department**	计算机科学与工程系 Department of Computer Science and Engineering
3.	**课程编号 Course Code**	CS329
4.	**课程学分 Credit Value**	3
5.	**课程类别 Course Type**	专业核心课 Major Core Courses
6.	**授课学期 Semester**	秋季 Fall
7.	**授课语言 Teaching Language**	中英双语 English & Chinese
8.	**授课教师、所属学系、联系方式（如属团队授课，请列明其他授课教师） Instructor(s), Affiliation& Contact （For team teaching, please list all instructors）**	郝祁，副教授，计算机科学与工程系，haoq@sustech.edu.cn Qi Hao, Associate Professor, Department of Computer Science and Engineering haoq@sustech.edu.cn
9.	**实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact**	贾艳红，教学实验师，计算机科学与工程系，jiayh@mail.sustech.edu.cn Yanhong Jia, Teaching engineer, Department of Computer Science and Engineering, jiayh@mail.sustech.edu.cn
10.	**选课人数限额(可不填) Maximum Enrolment （Optional）**	

11.	授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other（Please specify）	总学时 Total
	学时数 Credit Hours	32		32		64

12.	先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	MA103A 线性代数 I-A Linear Algebra I-A MA212 概率论与数理统计 Probability and Statistics
13.	后续课程、其它学习规划 Courses for which this course is a pre-requisite	无
14.	其它要求修读本课程的学系 Cross-listing Dept.	无。不接受跨系选课。 None. Inapplicable for other departments other than CSE.

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

本课程本课程旨在提供基于统计视角的机器学习和特征提取的基础知识，涉及贝叶斯方法与深度学习框架。 预期学生理解各类机器学习方法的基本思想与原理，并掌握基于模型和数据驱动的机器学习系统设计和集成技能。

This course aims to provide fundamental knowledge about machine learning and feature extraction from statistical perspectives, for both Bayesian approaches and deep learning frameworks. Students are expected to learn common ideas and principles of various machine learning paradigms, and to acquire model-based and data-driven machine learning system design and integration skills.

16. 预达学习成果 Learning Outcomes

在学习完成时，学生应该掌握如下技术的原理和编程技巧：指数家族概率模型，线性分类/回归，非线性分类/回归，特征选择/提取，支持向量机，神经网络，高斯混合模型，隐式马尔科夫模型，贝叶斯图模型，马尔科夫决策过程以及贝叶斯强化学习。

Upon completion of this course, the students should grasp the fundamental knowledge and programming skills of exponential family probability distribution models, linear and nonlinear classification/regression, feature selection/extraction, support vector machine, neural networks, Gaussian mixture models, hidden Markov models, Bayesian graph models, Markov decision process and Bayesian reinforcement learning.

17. 课程内容及教学日历 （如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

第一周：导论

- 课程介绍
- 机器学习导论

[实验课] 介绍实验课软件、工具包、网络资源、参考书籍。

第二周：绪论

- 曲线拟合与正则化
- 概率与高斯分布
- 推断与决策
- 熵与信息

[实验课] 在给定数据集上，实现指定的算法，完成相关任务，可以调用库。

第三周：指数家族

- 二项分布
- 多项分布
- 高斯分布
- 指数家族

[实验课] 学习使用 scikit-learn 对数据进行分析和预处理。

第四周：线性回归模型

- 线性基函数模型
- 最大似然估计
- 线性回归
- 预测分布

[实验课] 用 Python 实现决策树与线性模型，完成分类与回归任务。

第五周：项目开题报告

[实验课] 开题报告。

第六周：线性分类模型

- 判别函数
- Fisher 判别
- 感知机
- 逻辑回归
- 推断与生成模型

[实验课]利用线性模型，完成手写数字识别。

第七周：神经网络

- 前馈网络

- 反向传播
- Jacobian 矩阵与 Hessian 矩阵
- 正则化
- 贝叶斯神经网络
- 卷积神经网络与对抗生成网络

[实验课] 使用 TensorFlow 搭建一个 CNN，完成手写数字识别。

第八周：特征选择

- 主成分分析
- 特征选择方法
- 贝叶斯特征学习
- 深度网络特征学习

[实验课] 实现 CNN 网络提取视频中物体特征，完成运动物体检测与识别

第九周：稀疏核机

- 分类支持向量机
- 回归支持向量机
- 分类相关向量机
- 回归相关向量机

[实验课] 实现支持向量机，并对视频进行目标检测。

第十周：混合模型与期望最大学习

- K 均值聚类算法
- 高斯混合模型
- 期望最大算法

[实验课] 实现一个聚类算法，并在一张图上完成语义分割。

第十一周：隐式马尔科夫模型

- 隐式马尔科夫模型概念
- 隐式马尔可夫模型的最大期望算法
- 前向后向算法
- 加和乘积算法
- 维比特算法
- 卡尔曼滤波与粒子滤波

[实验课] 使用隐马尔科夫模型，完成对交通状况的预测。

第十二周：图模型

- 贝叶斯网络
- 条件独立

- 马尔可夫随机场
- 图模型中的推断

[实验课] 实现 EM 算法，去除图像噪音。

第十三周：马尔可夫决策过程

- 动态规划
- 马尔可夫决策过程
- 部分可观察马尔可夫决策过程
- 值迭代
- 策略迭代

[实验课] 实现马尔可夫决策过程中值迭代与策略迭代，完成对机器人的规划。

第十四周：贝叶斯强化学习

- 强化学习
- Q-learning
- TD-learning
- 贝叶斯强化学习

[实验课] 实现强化学习中 Q-learning，完成对机器人的规划。

第十五周：贝叶斯学习与深度学习

- 贝叶斯深度学习
- 深度贝叶斯学习

[实验课] 实现深度贝叶斯学习 VAE 算法，完成对图像的压缩。

第十六周：总结和复习

[实验课] 复习、答疑。

Week 1: Introduction

- Introduction to Course
- Introduction to Machine Learning

[Lab] Introduction to the software, tools, online resources that will be used in this module and suggested textbooks.

Week 2: Preliminary

- Curve Fitting and Regularization
- Probabilities and Gaussian Distributions
- Inference and Decision
- Entropy and Information

[Lab] Practicing classification, regression and clustering on the given dataset using Scikit-Learn libraries.

Week 3: Exponential Family

- Binomial Distributions
- Multinomial Distributions
- Gaussian Distributions
- Exponential Families

[Lab] Analyzing and processing data by using of scikit-learn toolboxes.

Week 4: Linear Models for Regression

- Linear Basis Function Models
- Maximum Likelihood
- Linear Regression
- Predictive Distribution

[Lab] Implementing Decision Tree for data classification and regression.

Week 5: Proposal Presentations

[Lab] Final Project proposal.

Week 6: Linear Models for Classification

- Discriminant Functions
- Fisher Discriminant
- Perceptrons
- Logistic Regression
- Inference and Generative Models

[Lab] Implementing linear models to classify MINIST datasets.

Week 7: Neural Networks

- Feedforward Network
- Backpropagation
- Jacobian Matrix & Hessian Matrix
- Regularization
- Bayesian Neural Networks
- CNN and GAN

[Lab] Implementing CNNs to classify MINIST datasets with TensorFlow.

Week 8: Feature Selection

- Principle component analysis
- Feature selection methods
- Bayesian feature learning
- Deep networks for feature learning

[Lab] Implementing CNNs to detect and classify objects with TensorFlow.

Week 9: Sparse Kernel Machine

- SVM for Classification

- SVM for Regression
- RVM for Classification
- RVM for Regression

[Lab] Implementing SVM to classify cars in the video.

Week 10: Mixture Models and EM Learning

- K-means Clustering
- Gaussian Mixture Model
- Expectation and Maximization

[Lab] Implementing clustering algorithms for image segmentation.

Week 11: Hidden Markov Models

- Hidden Markov Models
- EM for HMM
- Forward-Backward Algorithm
- Sum-Product Algorithm
- Viterbi Algorithm
- Kalman and Particle Filters

[Lab] Implementing HMM algorithms for stock prediction.

Week 12: Graphical Models

- Bayesian Networks
- Conditional Independence
- Markov random fields
- Inference in Graphical Models

[Lab] Implementing EM algorithms for noise removal.

Week 13: Markov Decision Process

- Dynamic programming
- Markov Decision Process
- Partially Observable MDP
- Value Iteration
- Policy Iteration

[Lab] Implementing MDP algorithms for robot path planning.

Week 14: Bayesian Reinforcement Learning

- Reinforcement learning
- Q-learning
- TD-learning
- Bayesian reinforcement learning

[Lab] Implementing Q-learning algorithms for robot path planning.

Week 15: Bayesian Learning and Deep Learning

- Bayesian deep learning
- Deep Bayesian learning

[Lab] Implementing VAE algorithms for image compression.

Week 16: Summary & Revision

[Lab] Final projects.

18. **教材及其它参考资料 Textbook and Supplementary Readings**

1. Bishop C. M. Pattern recognition and machine learning [M]. springer, 2006.
2. Sutton S. R and Barto G. A., Reinforcement Learning: An Introduction [M]. MIT Press, 1998.
3. Harrington P., Machine Learning in Action [M]. Manning, 2012

课程评估 ASSESSMENT

19.

评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance				
课堂表现 Class Performance				
小测验 Quiz		10%		5 次 Five times
课程项目 Projects		10%		Final project 开题报告 Final project proposal report
平时作业 Assignments		30%		8 次理论作业，12 次实验作业 8 times homework & 12 lab assignments
期中考试 Mid-Term Test		20%		开卷考试 Open book exam
期末考试 Final Exam		20%		闭卷考试 Closed book exam

期末报告 Final Presentation		10%		Final project 结题报告 Final project report
其它（可根据需要改写以上评估方式） Others (The above may be modified as necessary)				

20. 记分方式 **GRADING SYSTEM**

☑ A. 十三级等级制 **Letter Grading**
☐ B. 二级记分制（通过/不通过） **Pass/Fail Grading**

课程审批 REVIEW AND APPROVAL

21. **本课程设置已经过以下责任人/委员会审议通过**
This Course has been approved by the following person or committee of authority