



INSTITUT TEKNOLOGI SEPULUH NOPEMBER (ITS)
FAKULTAS TEKNOLOGI ELEKTRO DAN INFORMATIKA CERDAS
DEPARTEMEN TEKNIK ELEKTRO
Program Studi Sarjana (S1) Teknik Telekomunikasi

1	Nama Mata Kuliah / Course Name : Kecerdasan Buatan dan Machine Learning dalam Telekomunikasi / <i>Artificial Intelligence and Machine Learning for Telecommunications</i>
2	Kode Mata Kuliah / Course Code : EL234505
3	Kredit / Credits : 2 SKS
4	Semester / Semester : 5

Deskripsi Mata Kuliah / Course Description

Permasalahan pada telekomunikasi umumnya diselesaikan dengan menggunakan pemodelan, seperti terlihat pada sistem komunikasi digital, pengkodean sumber dan kanal, dan sejumlah kinerja yang mendekati batas teoritik telah dicapai, khususnya untuk point-to-point. Pada sistem komunikasi yang datang, di mana terdapat perangkat komunikasi (multiuser) dalam jumlah besar yang terlibat, permasalahannya menjadi sangat kompleks. Di lain pihak, pada beberapa tahun terakhir metode-metode berbasis AI dan ML memberikan peningkatan kinerja yang signifikan pada berbagai aplikasi, misal: klasifikasi citra, pengenalan suara, dll. Pada mata kuliah ini dipelajari tentang konsep dasar dan prinsip pada AI dan ML, antara lain: decision tree, klasifikasi, jaringan syaraf tiruan, perceptron, SVM, supervised dan unsupervised learning, deep learning, serta aplikasinya pada berbagai permasalahan di telekomunikasi, misalnya estimasi kanal, prediksi trafik, spectrum sharing, dan komunikasi dengan energi yang efisien. Mahasiswa akan mengimplementasikan algoritma-algoritma ML dengan perangkat lunak dan secara berkelompok akan mengerjakan tugas proyek dengan topik yang terkait.

Telecommunication problems are generally solved using modeling, as seen in digital communication systems, source and channel coding, and several performances that approach theoretical limits, especially for point-to-point communication. In incoming communication systems, where a large number of communication devices (multiusers) are involved, the problem becomes very complex. On the other hand, in recent years, AI and ML-based methods have provided a significant performance improvement in various applications, such as image classification, speech recognition, etc. In this course, students will learn about the basic concepts and principles of AI and ML, including decision trees, classification, artificial neural networks, perceptron, SVM, supervised and unsupervised learning, deep learning, and their applications in various telecommunications problems, such as channel estimation, traffic prediction, spectrum sharing, and energy-efficient communication. Students will implement ML algorithms with software and work on a group project related to the course topic.

Capaian Pembelajaran Lulusan (CPL) Yang Dibebankan Mata Kuliah / Program Learning Outcomes Charged to The Course

1. (CPL-04) Mampu menerapkan ilmu pengetahuan alam dan matematika serta teknologi dan rekayasa informasi untuk memperoleh pemahaman komprehensif pada bidang Teknik Telekomunikasi.
(PLO-04) Able to apply knowledge of sciences, mathematics, and information technology to acquire comprehensive understanding of engineering principles in Telecommunication Engineering
2. (CPL-07) Mampu mengidentifikasi, memformulasikan, menganalisis, dan menyelesaikan permasalahan kompleks di bidang teknik telekomunikasi
(PLO-07) Able to identify, formulate, analyze, and solve the complex problems in the field of Telecommunication Engineering
3. (CPL-08) Mampu mengetahui dan mengaplikasi metode dan keahlian sesuai perkembangan terkini di bidang ilmu pengetahuan dan teknologi untuk menyelesaikan permasalahan di bidang Teknik Telekomunikasi dengan mengedepankan nilai-nilai universal
(PLO-08) Able to know and apply methods, skills according to the latest developments in the field of science and technology to solve electrical engineering problems by prioritizing universal values

Capaian Pembelajaran Mata Kuliah / Course Learning Outcomes

1. Mampu menjelaskan konsep-konsep dasar ML: linear regression, jaringan syaraf tiruan, supervised and unsupervised learning, DNN, CNN / *Able to explain basic concepts of ML: linear regression, artificial neural networks, supervised and unsupervised learning, DNN, CNN.*
2. Mampu memformulasikan permasalahan klasifikasi dan regresi logistik dan menyelesaikan dengan metode yang sesuai / *Able to formulate classification and logistic regression problems and solve them using appropriate methods.*
3. Mampu mengimplementasikan JST dengan perangkat lunak R, python dan Matlab / *Able to implement ANN with R, Python, and Matlab software.*
4. Mampu menjelaskan aplikasi machine learning pada berbagai permasalahan pada telekomunikasi, antara lain: estimasi kanal, traffic prediction, radio resource allocation, spectrum sharing, / *Able to explain the applications of machine learning in various telecommunication problems, such as channel estimation, traffic prediction, radio resource allocation, spectrum sharing.*
5. Mampu mengerjakan tugas proyek dalam suatu kelompok untuk sebuah topik yang terkait penerapan AI dan ML pada telekomunikasi / *Able to work on a group project for a topic related to the application of AI and ML in telecommunications.*

Pokok Bahasan / Contents

1. Pengantar dan review materi penunjang: aljabar linier, kalkulus, probabilitas, statistik / *Introduction and review of supporting materials: linear algebra, calculus, probability, statistics*
2. Decision tree learning / *Decision tree learning*

3. Linear classification and linear regression / *Linear classification and linear regression*
4. Klasifikasi probabilistik / *Probabilistic classification*
5. Clustering / *Clustering*
6. Jaringan Syaraf Tiruan dan Backpropagation / *Artificial Neural Networks and Backpropagation*
7. Deep Learning dan dasar-dasar DNN / *Deep Learning and basics of DNN*
8. Convolutional neural network / *Convolutional Neural Network*
9. Pemrograman jaringan syaraf tiruan / *Programming of Artificial Neural Networks*
10. Aplikasi 1: Estimasi kanal pada sistem komunikasi nirkabel / *Application 1: Channel estimation in wireless communication systems*
11. Aplikasi 2: Traffic Prediction dan User Mobility / *Application 2: Traffic prediction and user mobility*
12. Aplikasi 3: Sistem Komunikasi Nirkabel untuk ML / *Application 3: Wireless Communication System for ML*

Prasyarat / Pre-requisite

Sistem Komunikasi, Aljabar Linier, Probabilitas dan Statistik, Proses Stokastik, Algoritma Pemrograman / *Communication Systems, Linear Algebra, Probability & Statistics, Algorithms and Programming*

Pustaka / Reference

Utama / Primary :

1. Yonina C. Eldar, Andrea Goldsmith, Deniz Gunduz, & H. Vincent Poor, eds., "*Machine Learning and Wireless Communications*," Cambridge University Press, 2022.
2. Kevin P. Murphy, "*Probabilistic Machine Learning: An Introduction*," MIT Press, 2022.
3. Fa-Long Luo, ed., "*Machine Learning for Future Wireless Communications*," John Wiley & Sons, 2020.

Pendukung / Support :

1. Ruisi He & Zhiguo Ding, eds., "*Applications of Machine Learning in Wireless Communications*," IET, 2019.
2. Henrik Hellström, José Mairton B. da Silva Jr., Mohammad Mohammadi Amiri, Mingzhe Chen, Viktoria Fodor, H. Vincent Poor, & Carlo Fischione, "*Wireless for Machine Learning: A Survey*," Now, 2022.
3. Jong Chul Ye, "*Geometry of Deep Learning: A Signal Processing Perspective*," Springer, 2022