

CMSC 409:
Artificial Intelligence
<http://>

Virginia Commonwealth University,
Fall 2023,
Dr. Milos Manic
(mmanic@vcu.edu)

1

CMSC 409:
Artificial Intelligence
Session # 01
Topics for today

- Announcements
- Syllabus
- Course intro
 - *goals, topics, class description and syllabus*
- Class paper topics
 - *some ideas, illustrative papers from the past*
- AI and intelligence

2



CMSC 409: Artificial Intelligence

Announcements Session # 01

- Canvas
 - Slides, class paper instructions and template uploaded
- Prereqs
 - Must have the pre-reqs CMSC 401, MATH 310 (except when approved prior).
- Blackboard
 - All students should have access to this course – please verify
 - The 1st announcement posted, following communication via email
- Subject line and signature
 - *Please use specified in syllabus*

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Page 3

Session 01, Updated on 8/24/23 8:38:20 AM

3



Artificial Intelligence

Class period: Tue/Thu 9:30pm–10:45am edt

Instructor:

Dr. Milos Manic, phone (804) 827-3999, ERB 2328, mmanic@vcu.edu;

Office hours (Zoom): Thu 10:45am–12:45pm (please make an appointment)

TA:

Sandun Bandara, mavikumbureh@vcu.edu, Victor Cobilean
cobileanv@vcu.edu, ERB 2333

Office hours (Zoom): Thu 3:30 - 4:30pm (please make an appointment)

Class web page: [Canvas](#)

Exams: Oct 19, Dec. 12 ([mark your calendars NOW](#))

Textbooks:

• Stuart Russell and Peter Norvig , Artificial Intelligence: A Modern Approach, , Prentice Hall, 2009

• Jeff Heaton, Artificial Intelligence for Humans, Volume 1: Fundamental Algorithms, Independent Publishing Platform, Heaton Research Inc, 2013

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4

Goals & Topics of this course

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5

Artificial Intelligence

Goals: This course provides first year graduates and seniors with the theoretical and practical tools for designing, simulating and implementing Artificial Intelligence Systems. Course equips students with tools to attack basic research and application oriented problems in intelligent systems.

PAPER (not mandatory)!

Helpful prerequisites by topics:

1. Linear algebra and matrix manipulation
2. Some computer programming skill Java, MATLAB, C++, PERL, or similar

We will be using mostly Matlab!

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6

3

Artificial Intelligence

Paper topic – some ideas (more on class web page)

- These are some examples of topics of papers from previous years.
- Pattern recognition
 - Pattern Recognition and Conversion of Japanese Hiragana to Roman Characters
 - Artificial Neural Network For Automated Prediction of Popularity of Digitized Images
- Clustering
 - Good Vibrations: Investigating Neural Network Applications in
 - Prognostics of Jet Engine Ball Bearings
 - Single Neuron Classification of Non-Linearly Separable Data
- GA
 - Evolving Neural Networks Using Particle Swarms
 - CBAC Optimization for Artificial Neural Network (Cluster Based Averaged Crossover to converge in Particle swarm time)

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7

Artificial Intelligence

Paper topic – some ideas (more on class web page) (cont.)

- These are some examples of topics of papers from previous years.
- ECE problems
 - Implementing the 2-bit A/D Converter using the Counterpropagation Networks
 - Neural protective relay for a circuit breaker.
- IDS
 - Fuzzy-Neuro Networks for Intrusion Detection
- CE/ME problems
 - Bed Load Sediment Transport Estimation Using CI
 - Implementing a CI System to Solve the Inverse Kinematics of a Biologically Inspired Robotic Cat Leg
- Intelligent controllers
 - Road recognition for an autonomous vehicle
 - Control of Underwater Autonomous Vehicles Using Neural Networks

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8

Your “zeroth” assignment (deadline Aug.31)

- A:**
1. Form a team (team lead + up to 2 members)
 2. Provide information in [google document](#)
 3. Inform Instructor (mmanic@vcu.edu) & TAs

Sandun Bandara (mavikumbureh@vcu.edu),

Victor Cobilean <cobileanv@vcu.edu>

Note: Team lead should always keep team members in cc

- B:**
1. Send an email to Instructor & TA:
 2. Use subject line [CMSC 409] Your Name, Background
 3. Describe your professional/academic background (briefly)
 4. Describe your interests in AI and course expectations

I receive a large number of emails on daily basis. Please use this subject line so your email ends up in right place in my Inbox. If any urgent matter arises, please append your subject line with “ – URGENT”.

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9

1. Form a team (team lead + up to 2 members)

2. Provide information in

<https://docs.google.com/spreadsheets/d/1YMP0tcAzOeB4sH9OU4OvvX9h3afKOOGn/edit#gid=697412957>

3. Inform Instructor (mmanic@vcu.edu) & TAs

Sandun Bandara (mavikumbureh@vcu.edu), Victor Cobilean <cobileanv@vcu.edu>

Note: Team lead should always keep team members in cc

<- Populate this document by Aug.31

Important: If you are looking for additional team members, please contact below:

Group Name	# team members	First Name	Last Name	Canvas Group Status
LastName1_LN2_LN3	3	FirstName1	LastName1	Not Created
		FirstName2	LastName2	Not Created
		FirstName3	LastName3	Not Created
	3			Not Created
	3			Not Created
	3			Not Created
	2			Not Created
	3			Not Created
	3			Not Created
	3			Not Created
	3			Not Created
	2			Not Created
	1			Not Created
	2			Not Created
	2			Not Created
	3			Not Created
	2			Not Created
	1			Not Created
	2			Not Created

Name 1, Name 2,... Looking for a team, please contact me if you are looking for another team member (contact email):

Created

Session 01, Updated on 8/24/23 8:38:20 AM

10

Canvas:

Zoom (office hours)

- Login to <https://vcu.zoom.us/> - that activates your zoom account in case you do not have it already
- This is the licensed account

This option is activated => Only authenticated users can join: Sign in to Zoom

11

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- Zoom Chat (contact me any time)
 - Login to zoom app
 - Start Chat
 - If there is a green dot next to my name, I am not in Zoom call
 - You can “chat me” here during and outside office hours

Session 01, Updated on 8/24/23 8:38:20 AM

12

Tentative Course Schedule

- Intro into (and just a very short history of) AI
- Basics of linear systems and matrices, Basics of statistics concepts, Basics of MATLAB modeling environment
- Data and its meaning

LEARNING

- Basics of unsupervised learning
- Knowledge acquisition from data, Linear models
- Neural networks

EMBEDDING HUMAN STRUCTURED KNOWLEDGE

- Fuzzy logic
- Evolutionary computing (if times allows)
- **Problems solving by AI techniques (projects)**

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13

The starting part of the course is about the data and how one learns from experimental data.

WHY?

Because we live in an information age? - Possibly!
Because we live in a knowledge society? - Possibly YES!

Because we live surrounded by an **OCEAN OF 'DATA'**
YES, FOR SURE!

And, I mean **ALL** possible 'data' because, we and our devices are surrounded by all imaginable measurements, images, sounds, smells, records, etc.

We want - to produce data, to transfer it, to compress it, to use it, to process it, to reuse it, to filter it, etc .

But primarily, we want to LEARN FROM DATA, a.k.a., examples, samples, measurements, records, observations, patterns

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14

Applications, classics:

- increase in sleep depending on the drug,
- pulmonary function modeling by measuring oxygen consumption,
- head length and breadths of brothers,
- classification of the Brahmin, Artisan and Korwa caste based on physical measurements,
- biting flies (genus: *Leptoconops*) data for classification of the two species of flies,
- battery-failure data dependency and regression,
- various financial and market analysis (bankruptcy, stock market prediction, bonds, goods transportation cost data, production cost data, etc.),
- study of love and marriage regarding the relationships and feelings of couples,
- air pollution data classification, college test score classification and prediction, crude oil consumption modeling, closeness between 11 different languages, and so on.

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15

TODAYS (primarily **NON-linear) applications:**

Note the following strong fact -> there is no field of human activities today, left untouched by learning from data!!!

Statistical learning is very, very hot nowadays - find patterns, identify, control, make prediction, make decisions, develop models, search, filter, compress,, and some today's applications are:

- Deep learning, adversarial learning, generative design, XAI
- computer graphics, animations, image analysis & compression, face detection, face recognition,
- text categorization, media news classification, multimedia (sound video) analysis
- bioinformatics - gene analysis, disease's study
- time series identification - financial, meteorological, hydro, biomedicine signals, all possible engineering signal processing
- predictions - sales, TV audience share, investments, ..etc.

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16

Few more examples:

- Banks: Fraud checks detection
- Google, Microsoft et al: Targeted advertising
- Supermarkets: Promotion planning
- Call centers: Speech recognition
- Scanners: Optical character recognition
- Web pages classification, Text categorization
- Post office: Zipcode handwriting recognition
- Credit cards: Loan default prediction
- Stock market: Statistical arbitrage
- Drug design: Drug candidate screening
- Large Hadron Collider: Particle screening
- Airport scanner: Explosives, Drugs, Arm, Faces

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17

Basic notation for this class:

- Unless clear from the context, or defined otherwise, the following applies:
 - **scalars** are low-case italics – w, y, a, b, \dots
 - **vectors** are low-case bold – $\mathbf{x}, \mathbf{y}, \mathbf{w}, \dots$
 - **MATRICES** are capitals bold – $\mathbf{X}, \mathbf{A}, \mathbf{G}, \dots$
- **Vectors** are always column vectors say $\mathbf{x}(n, 1)$. Hence, $\mathbf{x}' = \mathbf{x}^T$ is an $(1, n)$ vector

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18

Setting the stage...three “types” of Machine Learning (ML)

- **Supervised** (pairs x_i, y_i are given for **all** data pairs, where x_i are the values of the independent variables, features, inputs, attributes and y_i are class labels)
- **Semi-supervised** (pairs x_i, y_i are given for **just a fraction** of data pairs)
- **Unsupervised** (only inputs x_i are given and no single label y_i is known)

We will be investigating all of the above...

What **IS** AI.....

What IS AI...?

Artificial = Made by humans; Created, produced - rather than natural.

Defining Intelligence – much harder!

- The capacity to **acquire and apply knowledge**.
- The **ability to learn** or understand things or to deal with new or trying situations: the skilled use of reason.
- Terminology.
 - Artificial Intelligence, Machine Learning, Computational Intelligence, (Fuzzy/Neural/Genetic), Deep learning

AI today...
*“data driven”
 takes many forms*

AI our attempt to build models of ourselves?

Who is NOT using AI today? Why?

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21

<http://www.people.vcu.edu/~mmanic/>

**AI, Machine Learning – anomaly detection
 (Crit.Inf., HMI, Networking (SDN), Visualization)**

Modern Heuristics Research Group
 Our main goals focus on theoretical and applied research in Computational Intelligence algorithms, such as Reinforcement Learning, Evolutionary Computation, and Unsupervised Learning techniques. We are applying these methods in areas of Energy, Cyber Security, Intelligent Control, Software Defined Networks, Robotics, Visualizations and others. Please check the list of publications of our research papers.

MHRG RESEARCH
 MHRG is involved in theoretical and applied Computational Intelligence in various different areas of industry

MHRG PROJECTS
 These projects are funded by various entities and are in applied Computational Intelligence

Our Publications
 View our publications

INL Idaho National Laboratory

CAES Center for Advanced Energy Studies

SD Robotics Informational Control & Intelligent Systems

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22

Research Overview

AI/ML in Resilience and Security



Milos Manic, Ph.D., FIEEE, Director, VCU Cyber Security Center, NSA CAE-CD, CAE-R
Director, MHRG Group, Virginia Commonwealth University, Richmond, VA, Joint Appt. INL



Virginia Commonwealth University
Modern Heuristics Research Group




Smart, Sustainable, Resilient, and Secure Cities

We view community resilience as data and **human knowledge** driven

DOE RUC (100 Resilient Cities) – capacity to survive, adapt, and grow, regardless of stressors (aging infrastructure, food, energy & water security, cyber attacks, etc.)

Role of Machine Learning and AI: connected, smart, efficient modern municipalities and critical infrastructures.

Holistic view: understanding sub-systems, **interdependencies**, and the risks cities face.



The diagram illustrates the integration of various city infrastructure components through a central data management system. It shows a flow from sensors and data collection points (e.g., weather station, traffic light, water meter) into a central cloud-based system. This system then manages resources like energy, water, and transportation, while also providing information to citizens via mobile devices and public displays. A legend on the right defines terms like 'Resilient Control Design', 'Autonomous Intelligent Cyber Sensor (AICS) AI cybersecurity for industrial control systems', 'Vulnerabilities in Power Grids', and 'Resilient Control Design'.

Cybersecurity and Resilience

Dr. Milos Manic's research areas: Data Analytics, Machine Learning (ML) and Artificial Intelligence (AI) approaches applied to resilience and security of critical infrastructures.

ML driven cybersecurity: anomaly detection, holistic CPS cyberhealth and state awareness, intelligent controls, software vulnerability identification.

Explainable AI (XAI): trust in AI systems; transparency of complex AI models (e.g. deep learning).

Adversarial machine learning: exploits/strengthening AI algorithms and data.

Embedding domain-knowledge in ML: combining physics based (diff.) driven (AI/ML) modeling of complex control systems.



AI fuel efficient transportation



TEMST - Targeted Energy Management Toolset for Building Managers



Visual Data Mining VCU Virtual Reality Lab

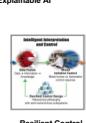


Autonomous Intelligent Cyber Sensor (AICS) AI cybersecurity for industrial control systems

Resilient & Scalable Cyber State Resiliency through Big Data



Vulnerabilities in Power Grids



Resilient Control Design



Explainable AI
VTR

• Over 40 invited talks on ML in critical infrastructures, big data integration, nuclear security and energy resiliency, and intelligent human-machine interfaces.

• DOE, NASA, and USGS awards, and technology world innovations in 2018.

• Over 200 peer-reviewed publications, 12 book chapters, 35 journals, 8 IEEE Transactions Editorials

• Over 40 research efforts as PI/Co-PI

• Organized the first International Committee on Resilience and Security in Industry

• 10 advisory awards for outstanding research/development

• IEEE IES General Chair and IEEE ICENON 2018 (<http://ieeicon2018.org/>), IEEE HSI 2019 (<http://ieehsi2019.welcomethis.org>)

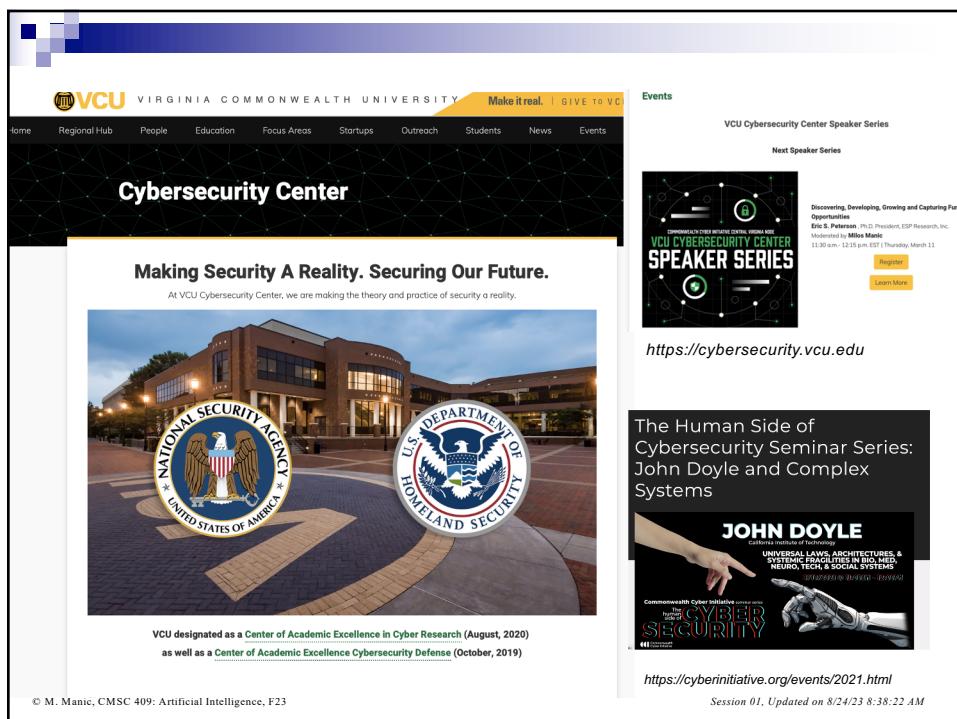
<http://www.people.vcu.edu/~mmanic>



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Session 01, Updated on 8/24/23 8:38:21 AM

23



The screenshot shows the VCU Cybersecurity Center website. The header includes the VCU logo, "VIRGINIA COMMONWEALTH UNIVERSITY", and navigation links for Home, Regional Hub, People, Education, Focus Areas, Startups, Outreach, Students, News, and Events. A yellow banner at the top right says "Make it real. | GIVE TO VC". Below the header is a large banner with the text "Cybersecurity Center" and a subtitle "Making Security A Reality. Securing Our Future." It features a photograph of a modern building at dusk with two large circular emblems in the foreground: the National Security Agency seal and the Department of Homeland Security seal. Text below the photo states: "At VCU Cybersecurity Center, we are making the theory and practice of security a reality." A footer at the bottom left mentions VCU's designation as a Center of Academic Excellence in Cyber Research and Cybersecurity Defense. The right side of the page displays event details for the "VCU Cybersecurity Center Speaker Series" featuring John Doyle, along with a registration link.

Events

VCU Cybersecurity Center Speaker Series

Next Speaker Series

Discovering, Developing, Growing and Capturing Future Opportunities
Eric S. Peterson, President, ESP Research, Inc.
Moderator: Miles Marin
11:30 a.m. - 12:15 p.m. EST | Thursday, March 11

[Register](#)

[Learn More](#)

<https://cybersecurity.vcu.edu>

VCU designated as a Center of Academic Excellence in Cyber Research (August, 2020)
as well as a Center of Academic Excellence Cybersecurity Defense (October, 2019)

<https://cyberinitiative.org/events/2021.html>

Session 01, Updated on 8/24/23 8:38:22 AM

24

<https://rampages.us/mhrg/other/>

Other

Additional Reading Material
Selection of references (yes, some links may be very old):

- Links:
 - Artificial Intelligence, Ethics, HMI [references](#)
 - Artificial Neural Networks [references](#)
 - Deep Learning [references](#)
 - EEG, Brain-Machine Interfaces [references](#)
 - General Links on Computational Intelligence [references](#)
 - Intelligent Control [references](#) Computational Geometry [references](#)
 - Data mining [references](#)
 - Neuro robotics, Behavioral Robotics, Exoskeletons, Cognitive Control [references](#)
 - Smart grids and energy [references](#)
 - Reliability and Performability [references](#)
 - Web Concepts [references](#)
 - General (Impact factor, literature search, math software) [references](#)

Categories

- Media
- Projects
- Research
 - Control
 - Cyber Security
 - Energy
 - Intelligent Control
 - Open Flow/Networking
 - Other
 - Robotics
 - Trustworthy AI
 - Visualization
- Uncategorized

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25

Things to remember...

- Form teams asap
 - *populate in [google document](#)*
- Exam dates
 - *“save the date” in your calendars now!*
- Consider writing the class paper
 - *Great experience and can be used of topics!*
- Intelligence?
 - *The ability to learn!*

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26