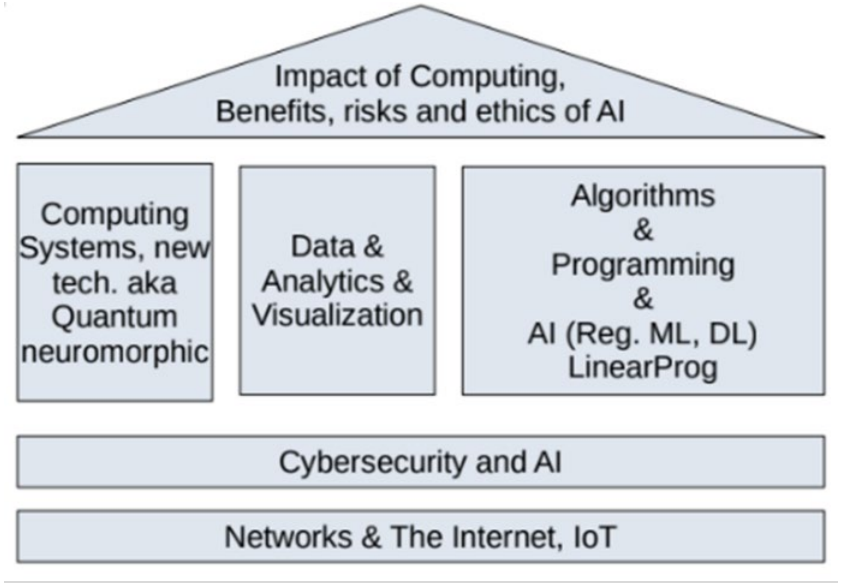
South Carolina Artificial Intelligence (AI) Standards Framework



Process Standards:

1. Foster an inclusive computing culture.
2. Collaborate around computing.
3. Recognize, define and analyze computational problems.
4. Create, test and refine computational artifacts.
5. Communicate about computing.
6. Design solutions for privacy, protect against bias and defend against cyber influences.

Theme	Standard
Computing Systems	1. Students will analyze the utilization of computing devices and investigate advancements in AI. 2. Students will solve relevant problems and design AI solutions using appropriate components, including software and hardware that contribute to computing devices.
Data and Analytics	3. Students will evaluate various data collection methods, data storage tools, data analysis tools, data representation tools. 4. Students will construct a computational model using large data sets. 5. Students will choose data types and data structures based on functionality, storage and performance tradeoffs.
Algorithms and Programming	6. Students will create, evaluate, and modify algorithms to express an idea or solve a problem. 7. Students will divide a task into sets of functional units that can be reused to compose a complex solution. 8. Students will plan, build, test, refine and document programs using text-based coding languages to solve problems with varying degrees of difficulty.
Impacts of Computing	9. Students will research and analyze historical and current computing and AI applications, describing their global impact. 10. Students will evaluate the evolving legal and ethical tradeoffs that shape computing and AI practices.
Security and Privacy	11. Students will research security and privacy protocols associated with AI and ML solutions and apply the protocols to protect the data throughout the processes.

Theme	Standard
Computing Systems	**1. Students will analyze the utilization of computing devices and investigate advancements in AI.**

Level 1	Level 2	Level 3	Level 4
Identify and relate how hardware and software are used within given AI solutions. Utilize a common troubleshooting process to identify software problems that involve the interpretation of error messages and common system malfunctions.	Utilize hardware and/or software to solve level-appropriate (domain-specific) problems. Identify applications, libraries, and software packages (e.g., MATLAB, R, Python, GNU, OCTAVE, or other open-source libraries) utilized within AI and machine learning (ML) industries.	Identify and use applications, libraries and software packages utilized within AI and ML industries specifically used for deep learning.	Design solutions for domain-specific problems utilizing appropriate AI and ML software and hardware.
	Compare and contrast concepts and uses of machine learning, deep learning, and general artificial intelligence.	Compare and contrast the types of machine learning, including supervised learning algorithms, unsupervised learning algorithms, and reinforcement learning algorithms.	Design solutions using the types of machine learning, including supervised learning algorithms, unsupervised learning algorithms, and reinforcement learning algorithms.

Theme	Standard
Computing Systems	**2. Students will solve relevant problems and design AI solutions using appropriate components, including software and hardware that contribute to computing devices.**

Level 1	Level 2	Level 3	Level 4
Articulate the impact that computing devices *and AI* have in real-world settings (e.g., traffic lights, medical devices, facial recognition).	Compare and contrast explainable and non-explainable AI and describe how both are used to systematically solve problems through the selection and integration of hardware and software components.	Recommend modifications for existing computing devices and software to improve functionality *and the user experience*.	Develop a solution to a given problem using appropriate hardware and software (e.g., sensor devices, Wi-Fi capabilities, specialized displays, runtime modules, operating systems, application programming interfaces (APIs).
Explain the difference between machine learning and human learning.	Identify supervised, unsupervised, reinforcement, and transfer learning types of machine learning) and provide examples of the types of problems they solve.	Identify and explain CNN, RNN, GAN types of neural networks and the image classification, speech recognition, deep fakes/creativity/art applications they are used in.	Identify and describe layers (input, hidden, output), activation functions, learning rules and transfer learning components of a neural network and explain how they function.
Identify and define the function of circuits, sensors, microcontrollers, motors, and other components used within given AI solutions.	Assemble an embedded or robotic system that use circuits, sensor(s), microcontroller, microcomputers, motor(s) to complete a specific task.	Write a program for an embedded or robotic system that makes a decision based on sensor/user input, controls mechanics of the robot, and completes a “human” task (e.g., delivers items, opens a door for someone, solves a puzzle, etc.).	

Theme	Standard
Computing Systems	**2. Students will solve relevant problems and design AI solutions using appropriate components, including software and hardware that contribute to computing devices.**

Level 1	Level 2	Level 3	Level 4
Explain the purpose and function of GPUs in decreasing the training time of machine learning and identify applications that use this approach in the real world. Explain the purpose and function of Tensor Processing Unit (TPU) as an AI accelerator application-specific integrated circuit (ASIC) for neural network machine learning and identify applications that use this approach in the real world.	Compare and contrast the pros and cons of using GPUs, TPUs, and FPGAs in data processing and performance improvements of AI-based applications.		
Describe how hardware and software are used to generate a provided database.	Justify hardware and software selections for structured data sets that rely on the collection of data from sensors.	Justify hardware and software selections for unstructured data sets that rely on the collection of data from voice recognition devices or camera data. Merge or join multiple data sources in order to synthesize to a single data set using matrix or vector strategies to impute missing data.	Evaluate the interoperability of various hardware and software components (e.g., databases, sensors, application programming interfaces (APIs)) with computing devices (e.g., desktops, laptops, tablets, smartphones, specialized devices like global positioning systems (GPSs)) to justify selections within a given solution.

Theme	Standard
Data and Analytics	**3. Students will evaluate various data collection methods, data storage tools, data analysis tools and data representation tools.**

Level 1	Level 2	Level 3	Level 4
Define numeric, text, date, graphics, and sound types of data used in computing and AI solutions.	Compare and contrast the various data collection methods, data analysis tools, and data representation tools.	Explain how different collection methods and tools influence the amount and quality of the data that is observed and recorded.	Justify the choice of a data collection method, data analysis tool, and data representation tool over alternate options.
Describe the various data storage tools and data organization methods as related to generated lists and 2D arrays.	Compare and contrast the various data storage tools and data organization methods.	Select methods of data organization and storage (e.g. local, portable or cloud storage), considering factors such as cost, speed, reliability, accessibility, privacy and integrity.	Evaluate the data storage needs of a computing solution (e.g., file compression) and explain the tradeoff between speed and compressed data storage.
Distinguish between various methods of data representation (i.e., analog, digital, binary).	Translate between various methods of data representation (i.e., analog, digital, ASCII, binary).	Analyze, utilize, and visually represent static data.	Analyze, utilize, and visually represent dynamic data and justify the use of streamlined data analysis, real-time classification or data storage needs.

Theme	Standard
Data and Analytics	**4. Students will construct a computational model using large data sets.**

Level 1	Level 2	Level 3	Level 4
Summarize how data is used within excel and other statistical software programs. Illustrate how data sets evolve when using iterative processing cycles (loops).	Compare and contrast the properties of a data set that could be used to explore a real-world (domain-specific) scenario or support a claim. Describe and construct a simple model of the data processing cycle (input-processing-output).	Create data sets to explore a real-world (domain-specific) scenario or support a claim. Define Big Data and describe how it is used in AI. Describe how AI uses data to make predictions or decisions.	Evaluate the use of large data sets to explore a real-world (domain-specific) scenario or support a claim.
Use common data analytics (e.g., mean, median and mode) to summarize a given set of data. Identify and explain the difference between correlation and causality when analyzing data.	Analyze one or more given datasets, describe the information the dataset provides, and identify the types of questions that it can and cannot be answered. Define and explain the difference between training, validation, and test datasets.	Use appropriate data analytics to validate predictions/outcomes (e.g., correlation coefficients, R^2, AUC, Precision, Recall, Specificity, Confusion Matrix, P-Value, F-Score etc.)	Describe the role of training data in determining the accuracy and margin of error of the model. Explain the difference between overfitting and underfitting data and justify the use of cross validation, combining weak algorithms or removing weak coefficients to safeguard against bias.
Identify various types of computational models and their uses for data composed of multiple data elements that relate to one another (e.g., population data may contain information about age, gender, height) (K – 12 Framework, 2016).	Compare and contrast various types of computational models and their uses for data composed of multiple data elements that relate to one another (e.g., population data may contain information about age, gender, height) (K – 12 Framework, 2016).	Evaluate the limitations of a computational model and the accuracy of inferences. Describe the biases of given data models that include both good and bad data examples.	Create a computational model using large data sets, make inferences, and address the limitations of the model.

Theme	Standard
Data and Analytics	**5. Students will choose data types and data structures based on functionality, storage and performance tradeoffs.**

Level 1	Level 2	Level 3	Level 4
Justify and use appropriate data types (e.g., lists, arrays and 2d arrays) in simple programs.	Determine when data structures (e.g., lists, arrays, tuples, stacks, queues, structures) are more appropriate than simple data types and incorporate them in programs.	Determine when external data structures (e.g., databases, flat files) are appropriate and incorporate them in programs.	Justify how data structures and abstraction are used to manage program complexity.

Theme	Standard
Algorithms and Programming	**6. Students will create, evaluate, and modify algorithms to express and idea or solve a problem.**

Level 1	Level 2	Level 3	Level 4
Describe and use the types of algorithms used for classification (e.g., decision trees, NN, logistic regression).	Describe and use the types of algorithms used for regression (e.g., decision trees, NN, linear regression).	Analyze and apply the types of algorithms used with non-linear applications (e.g., logistic regression, GBM, SVM, etc.)	Select the appropriate algorithm to address a domain-specific problem and justify the solution.
Identify machine learning techniques (Algorithms) that allow the computer to learn behaviors without explicit programming.	Model and explain how machine learning algorithms are learning "patterns" in data to construct internal representations that encode the relationship between inputs and outputs and result in a model for reasoning.	Model and explain how machines learn new behaviors due to changes/adjustments the learning algorithm makes to internal representations of a decision tree or neural network reasoning model.	Compare and contrast how supervised, unsupervised, and reinforcement learning algorithms adjust internal representations to learn for classification and prediction.
Design, build and test level-appropriate algorithms that use iteration, selection, sequence, and recursion.	Design, build and test level-appropriate algorithms that use linear regressions and describe existing outliers in the context of the programming solution. Use decision trees and linear regressions to make predictions and classifications.	Design, build and test level-appropriate algorithms that use value analysis and sentiment analysis (e.g., language data sets, books, images, traffic examples) to make predictions, for classification and segmentation.	Design, build and test level-appropriate algorithms that use appropriate techniques (e.g., dynamic programming, linear programming, policy iteration, value iteration) to solve Markov decision process problems and other complex decisions.

Theme	Standard
Algorithms and Programming	**6. Students will create, evaluate, and modify algorithms to express and idea or solve a problem.**

Level 1	Level 2	Level 3	Level 4
Illustrate the flow of execution of algorithms in level-appropriate programs including branching and looping. Evaluate multiple student-created algorithms and non-student-created algorithms in terms of time and space complexities (e.g., linear, and binary search options) +iterations (time) with a finite list.	Illustrate the flow of execution of algorithms in level-appropriate programs utilizing structured data and ML libraries (e.g., scikit). Design level-appropriate algorithms using structured data sets and ML libraries. Datasets that can be used include Wine Quality Dataset, Credit Card Fraud Dataset, Titanic Dataset.	Illustrate the flow of execution of algorithms in level-appropriate programs utilizing unstructured data and DL libraries (e.g., Tensorflow). Design level-appropriate algorithms using unstructured data and DL libraries. Datasets that can be used include MNIST (classifying handwritten numbers), CIFAR-10 (60k images over 10 classes), Fashion-MNIST (70k images over 10 classes).	Design and implement level-appropriate algorithms to address a domain-specific problem justifying the selection of AI tools.
Use a systematic approach to detect and resolve errors in a given algorithm.	Discuss classification errors, their causes, and the issues they cause within artificial intelligence and machine learning.	Identify and discuss common errors associated with the use of unstructured or DL data.	Use a systematic approach to prevent or mitigate classification errors within artificial intelligence and machine learning implementation algorithms.

Theme	Standard
Algorithms and Programming	**7. Students will divide a task into sets of functional units that can be reused to compose a complex solution.**

Level 1	Level 2	Level 3	Level 4
Decompose and explain tasks associated with given data sets (e.g., limited data libraries) into smaller, reusable parts to facilitate the design, implementation, and review of programs.	Decompose and explain tasks associated with structured data sets (e.g., Pandas) into smaller, reusable parts to facilitate the design, implementation, and review of programs.	Decompose and explain tasks associated with unstructured data sets (e.g., images, video, audio, languages) into smaller, reusable parts to facilitate the design, implementation, and review of programs.	Decompose and explain complex domain-specific tasks into smaller, reusable parts to facilitate the design, implementation, and review of programs.
Design and build a complex solution to a problem that incorporates reusable code e.g., student-created, application programming interfaces (APIs), libraries) to expedite the programming associated with a limited data library.	Design and build a complex solution to a problem that incorporates reusable code e.g., student-created, application programming interfaces (APIs), libraries) to expedite the programming associated with structured data sets.	Design and build a complex solution to a problem that incorporates reusable code e.g., student-created, application programming interfaces (APIs), libraries) to expedite the programming associated with unstructured data sets.	Design and build a complex solution to a problem that incorporates reusable code e.g., student-created, application programming interfaces (APIs), libraries) to expedite the programming needed to address a domain-specific task.

Theme	Standard
Algorithms and Programming	**8. Students will plan, build, test, refine, and document programs using text-based coding languages to solve problems with varying degrees of difficulty.**

Level 1	Level 2	Level 3	Level 4
Plan and develop programs when given limited data libraries using a process that incorporates development, feedback, and refinement for accuracy.	Plan and develop programs when given structured data sets using a process that incorporates development, feedback, and refinement for accuracy.	Plan and develop programs when given unstructured data sets using a process that incorporates development, feedback, and refinement for accuracy.	Plan and develop complex programs to address a domain-specific task that incorporates development, feedback, and refinement for accuracy.
Use common evaluation tools associated with limited data libraries (e.g.,?) and make refinements to improve accuracy. Evaluate a program through a review process (e.g., code review, beta testing, pilot group).	Use common evaluation tools associated with structured data sets (e.g., R^2, accuracy, recall, precision, F1 Score, confusion matrix) and make refinements to improve accuracy. Describe the existence of outliers associated with the given data set and evaluation results, expressing how the existing outliers will be used to improve program accuracy.	Use common evaluation tools associated with structured data sets (e.g., R^2, mean squared error, accuracy recall) and make refinements to improve accuracy. Describe the existence of outliers associated with given data set and evaluation results, expressing how the existing outliers will be used to improve program accuracy.	Implement version control to track program refinements. Systematically test programs using a range of test cases to meet design specifications (e.g., specific outcomes, functionality, user interface, error handling) (CSTA, 2017).
Identify and use appropriate documentation methods while developing programs (e.g., inline comments, procedure header, purposeful naming).	Document programs that use non-user-created resources (e.g., code, media, libraries) giving attribution to the original creator.	Document programs in order to make them easier to follow, test, and debug.	Justify design decisions by documenting the design process of complex programs (e.g., developer journal, digital portfolio, presentation).

Theme	Standard
Impacts of Computing	**9. Students will research and analyze historical and current computing and AI applications, describing their global impact.**

Level 1	Level 2	Level 3	Level 4
Research advancing and emerging technologies (e.g., artificially intelligent agents, blockchain, extended reality, Internet of Things (IoT), machine learning, robotics).	Research cutting-edge technologies that incorporate artificial intelligence and machine learning as a core component of its decision-making processes (e.g., autonomous vehicles, recommended purchase suggestions, speech recognition).	Research potential future outcomes, both positive and negative, of artificial intelligence and machine learning.	Research how AI, ML and computing is used in non-traditional computer science careers (e.g., sensors on soldiers' or firefighters' uniforms, robots to detect and diffuse explosive devices).
	Define and illustrate examples of big data (e.g., information collected from social media or smartphone use), highlighting data privacy implications.	Describe how individuals use big data is used to solve computing problems. Compare and contrast the benefits of using big data and the known security and privacy challenges.	Identify the ethical and privacy implications encountered in the curation, management, and monetization of data (e.g., harvesting, information overload, knowledge management repositories, sharing, summarizing).
	Discuss the advantages and disadvantages of advancing and emerging technologies over time (e.g., the impacts of artificial intelligence, virtual reality, and biometrics on productivity, job loss, inventions, quality of life, and globalization).	Research and describe the ethical, philosophical, and safety ramifications of the implementation of both weak and strong artificial intelligence.	Discuss the ethical, philosophical, and safety ramifications of emerging artificial intelligence and machine learning technologies. Research and describe the use of AI is an economic driver that makes new services possible and businesses more efficient.

Theme	Standard
Impacts of Computing	**10. Students will evaluate the evolving legal and ethical tradeoffs that shape computing and AI practices.**

Level 1	Level 2	Level 3	Level 4
Research and describe legal and ethical implications of computing and AI solutions.	Identify ethical and legal implications of computing and AI solutions involving a variety of data (e.g., design based on good data vs bad data).	Justify intended and unintended outcomes of computing and AI solutions (e.g., internal, and external activities including social media/online search use, purchase/use history, geolocation).	Distinguish among ethical, unethical, legal, and illegal computing and AI practices (e.g., fair-use, illegal music/video downloads, sharing copyrighted pictures/videos, black-hat hacking, white-hat hacking, AI design with intended bias).
Define and compare the ethical and legal implications of AI.	Identify and analyze examples of legal policies related to computing and AI, including why and how they were or are being developed.	Analyze real-world Artificial Intelligence scenarios to determine the ethical and legal implications.	

Theme	Standard
Security and Privacy	**11. Students will research security and privacy protocols associated with AI and ML solutions and apply the protocols to protect the data throughout the processes.**

Level 1	Level 2	Level 3	Level 4
Identify AI and ethics-related laws and analyze their effect on digital privacy, security, intellectual property, network access, contracts, and harassment.	Discuss security and privacy issues that relate to AI applications.	Research the security vulnerabilities of machine learning models and ways to mitigate them.	Research and evaluate the security issues relevant to machine learning model creation, storage, and usage.
Explain the ethical methods of collecting data from human subjects while protecting privacy and security for use in training machine learning models.	Evaluate the issues related to privacy and security in the development and use of AI and ML models. Research the ethical, security, and privacy issues that affect data gathering, storage and overall data quality that can contribute to bias in a model.	Evaluate methods of direct and indirect AI interaction, such as using AI-enabled systems, contributing data to a dataset, and trading privacy and security for access to an AI tool.	Apply data protection protocols within AI and ML solutions, addressing concerns throughout the data cycle-collection, storage and use of iterative processing algorithms.