

NVIDIA DGX-1 Deep Learning Environment

MRI: Acquisition of NVIDIA DGX-1 for Deep Learning

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Project Summary

Deep learning is the field of machine learning that, like the human brain, uses deep layers of neural networks to recognize patterns in digital representations of sounds, images, and other data and thus create algorithms to solve complex problems. Advances in the research topics of deep learning can innovate the world in communications, medicine, manufacturing, and transportation. However, deep learning requires powerful environments that consist of expensive hardware and software which hinders the learning and research of deep learning by students at universities and colleges. At the University of Colorado at Colorado Springs, we are a university that is currently involved in deep-learning research, therefore we are in need of the funds to buy the supercomputer NVIDIA DGX-1 to help teach our students deep learning topics.

The main goal of the University of Colorado, Colorado Springs is to acquire the supercomputer NVIDIA DGX-1 to help teach our students certain deep learning topics. If provided the funds to buy the NVIDIA DGX-1, it would help the university and our students in developing deep learning strategies. Our first objective is to further develop natural language processing including text analysis and text translation. The second objective is to further develop image analysis including computer vision. The third objective is to further develop medical image analysis that will aid in the research and diagnosis of medical abnormalities not easily detected such as tumors.

The benefits of getting the NVIDIA DGX-1 is the amount of help it would offer to teach our students these core objectives of deep-learning. With this knowledge, the students can then influence the university, community, and world to further research and develop topics of deep learning. Throughout their schooling career, students will be able to expand their knowledge of deep learning to have important technological experience to use in the work force. With this deep learning environment, our students are reach out into the community to other schools of all levels as well as business to increase their knowledge and usage of deep learning thus globally progressing the innovation of deep learning.

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Project Description

Introduction/ Executive Summary

Deep learning is a field of research that attempts to imitate the activity in layers of neurons in the neocortex of the human brain which consists of the 80% where thinking occurs (Hof 2016). The purpose of this software is to recognize patterns in digital representations of sounds, images, and other data that is then further applied to specific fields of deep learning. Further advances in machine intelligence can ingeniously transform the world in communications, medicine, manufacturing, and transportation. However, deep learning requires powerful environments consisting of expensive hardware and software, hindering the learning of individuals which puts a hold on technological advances using deep-learning research. With the power of a new deep learning environment, universities can have the support to teach their students while advancing deep learning.

The University of Colorado at Colorado Springs (UCCS) is one of these particular high-education institutions that needs the support of a deep learning atmosphere. As a university, we are ranked as one of the top Western regional universities by U.S. News and World Report and supports an enrollment of approximately 12,000 students (uccs.edu/about). Included in the accredited programs and degrees is the College of Engineering and Applied Sciences which houses degree programs through the Bachelor of Science and the unique Bachelor of Innovation. The successful computer science department is actively involved in deep-learning that provide our students with skills needed to develop the innovative deep-learning topics. However, we are in need of financial support for our program to buy a supercomputer to support our students as they study the deep-learning topics of artificial intelligence, image analysis, natural language processing, and medical image analysis.

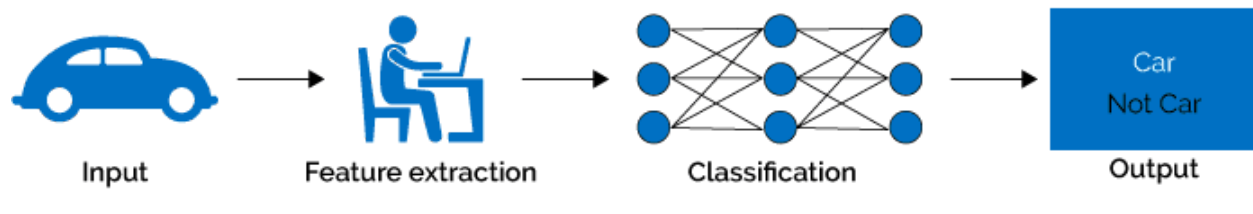
The goal of the University of Colorado Colorado Springs is to acquire the supercomputer NVIDIA DGX-1 to help teach our students certain deep learning topics. If provided the funds to buy the NVIDIA DGX-1, it would help the university and our students in developing deep learning strategies. Our first objective that the NVIDIA DGX-1 will help aid in, is the further development of natural language processing that includes but is not limited to text analysis and text translation. The second objective is to further develop image analysis including computer vision. The third objective is to further develop medical image analysis that will aid in the research and diagnosis of medical abnormalities not easily detected such as tumors.

The benefits of owning the NVIDIA DGX-1 would be to help teach our graduate students these core objectives to innovative deep-learning. With a deep learning environment, our students can reach out into the community and help other schools of all levels as well as business. As one of the only schools in southern Colorado acquiring this supercomputer environment, we can not only locally progress our research but be globally involved in with deep-learning research.

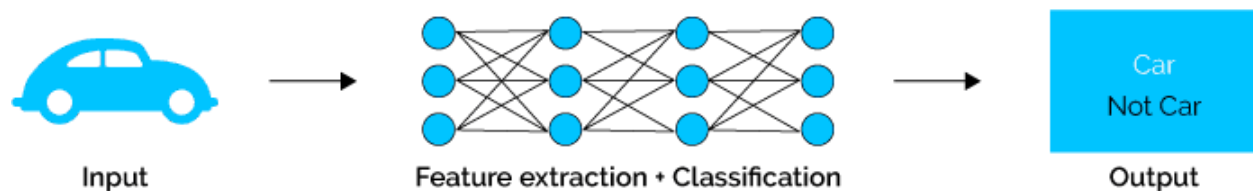
Background

Deep-learning is a class of machine learning that combines high performance computing, large sections of data, and large neuronal networks. Deep-learning is often compared to the human brain in which the computer mimics the brain's deep neural network with layers of neurons to simulate an artificial neural network. Furthermore, for the brain, a neuron will send signals to connected neurons in the layer above. For deep learning, the layers are responsible for performing a unique set of features based on outputs of previous layers (Jagreet 2017).

Machine Learning



Deep Learning



Source: <https://www.xenonstack.com/blog/log-analytics-with-deep-learning-and-machine-learning>

The image above describes how deep learning consists of layers that are responsible for training a unique set of features based on the outputs of previous layers. With this features, deep learning algorithms can be used to solve higher complex problems that consist of numerous layers better than machine learning (Jagreet 2017). As computer scientists continue to work on deep-learning, there has been improvements in mathematical formulas and more powerful computers, thus allowing deep-learning to advance as they can model more layers of virtual neurons than before.

Through deep-learning advances have been made in several fields of technological work, including artificial intelligence, natural language processing including text analysis, and image analysis including computer vision, and medical image analysis. More specifically, certain companies have been trying to further communicate with machines to develop Artificial Intelligence so the computers can do most of the tasks that a human would normally do. Some of these companies that signed a partnership on AI include Amazon, Google, Facebook, IBM, and Microsoft (Pablo 2016). The main goal with Artificial Intelligence research is to advance public and local understanding of this field to open the platform to further innovate the field.

One of these groups of individuals that deep learning would be beneficial to learn is students. It is important to train students in deep learning for a few reasons. Many people feel that AI is the way of the future and that businesses would do better if they would switch to AI and this deep learning thinking process. The more students that leave the university and have a

better grasp on this process, the more we will see the world transform in the direction of AI. There are current implementations of AI in certain companies that use it to engage with customers and answer questions, however, further development is needed (Thomas 2017).

The main reason why supercomputers are used in deep learning is because they are the only ones that have the GPU power to do so. We know how remarkable the human brain is: in a matter of seconds, decisions are made and processed. It is the same with AI and deep learning. In order for deep-learning to work well, you need to have a computer that can function like a brain essentially. As of today, deep learning environments can be very expensive not only of the actual environment but in time to set up the environment. More specifically, if UCCS were to acquire the NVIDIA DGX-1, it takes less time and money to set up therefore, leaving more time to focus on teaching our students and developing the world of deep learning.

Goals and Objectives

Main Goal: Acquire the NVIDIA DGX-1 to expand UCCS deep learning environment

The main goal of the Computer Science department at University of Colorado at Colorado Spring is to obtain the supercomputer NVIDIA DGX-1 to help teach our students deep learning so they can develop the industry of deep learning not only during their schooling but in the job field as well. UCCS currently does not have an adequate deep learning environment that can support our students throughout the learning and working process. More specifically, the Computer Science department had chosen the NVIDIA DGX-1 because it is one of the best deep learning environments that one could obtain.

The supercomputer works as soon as you power it up due to NVIDIA's deep learning software stack and the DGX-1 cloud management services rather than taking months like many other environments to integrate, configure, and troubleshoot the hardware and software (Supercomputer Datasheet). The NVIDIA DGX-1 creates effortless productivity for the University as it removes the need to continually optimize the deep learning software by using optimized software stacks resulting in saving of thousands of dollars (Supercomputer Datasheet). Because the NVIDIA DGX-1 integrates the most advanced deep learning software stack, it is three time faster than other GPU-based systems, leaving more valuable time for students to learn deep learning. Lastly, because the world is rapidly evolving in terms of technology and deep learning, the NVIDIA's software stack is maintained by monthly optimized framework releases as well as software upgrades to ensure that the environment is always up to date with the innovative advancements. With a money saving, time saving, fast, and renovating environment, UCCS and its students can get the best out of the supercomputer so they can be more dedicated to the research of deep-learning in specific topics. If this main goal is accomplished, then the UCCS students are able to further their knowledge of deep learning through research of several different topics of deep learning. With this knowledge, those individuals and UCCS as a whole is able to help innovate deep learning in Artificial intelligence as well as other topics to help technologically advance school, businesses, and individuals throughout the world.



Pictured above are images of the NVIDIA DGX-1 acquired from:

<https://www.nvidia.com/content/dam/en-zz/Solutions/Data-Center/dgx-1/dgx-1-ai-supercomputer-datasheet-v4.pdf>

<https://www.nvidia.com/en-us/data-center/dgx-1/>

Objectives

Objective 1: Natural Language Processing

After accomplishing the main goal of acquiring the supercomputer NVIDIA DGX-1, one objective of UCCS would be to use the deep learning environment for natural language processing. Natural language processing is the ability of a computer to analyze and understand the human language without the use of programming or artificial languages. There are previous understandings of natural language processing however, the human language is complex and machine learning algorithms are lacking enough information. With improvements in deep learning and artificial intelligence, advanced algorithms can effectively interpret the human language. UCCS and its students are further developing the following research topics for natural language processing:

Objective 1a: Semantic Textual Similarity

Learning the semantic similarities between sentences in natural languages is a difficult task for computers due to the inherent complexity of natural language. To contest this complexity, there

has been a rise in the research of complex architectures in the field of natural language processing. The research that UCCS is currently focusing on is the specific natural language processing topic of determining semantic textual similarity.

Objective 1b: Semantic Role Labeling

Semantic Role Labeling is a natural language processing topic that involves the figuring out of the different semantic roles that different words play in a sentence. Those roles are then defined in reference to something whether that be some concept to some verb. UCCS is specifically involved in the research of frame semantic parsing which is the roles that words play are tied to the different semantic frames that are contained in a given sentence.

Objective 1c: Vector Semantic of Summaries and Sentences

Used throughout natural language processing is vector semantics. UCCS explores the application of vector semantics to the current problem of automatic summarization. Based on current research, it has been found that several properties of vector semantics is useful for this purpose. More specifically, UCCS shows that similarity between sentence vectors and document vectors is strongly correlated with sentence importance. Furthermore, UCCS has discovered that this is the first usage of specific dimensions of sentence embedding in effective summaries, therefore, UCCS would continue the further research of vector semantics for automatic summarization.

Objective 2: Image Analysis

After the main goal is met and UCCS has the NVIDIA DGX-1, the second objective of the students at UCCS would be to use the deep learning supercomputer for image analysis. Image analysis is the converting of information in images into other forms that could be used to extract and characterize the content, looking for meaningful information. The human visual cortex is the sector that handles image analysis for extracting high level information and deep learning attempts to mimic this sector to perform complex computations. The students at UCCS are researching the following topics to improve image analysis:

Objective 2a: Image Splicing Detection

With the increase of images in technology, there is also an increase for the need of digital image forgery detection. One of methods of forgery detection, is splicing localization done by detecting and highlighting a break in a boundary between the original image's content and foreign spliced content. Previous splicing detection methods involved the use of handcrafted filters and features within a neural network. UCCS is focused on the research of neural networks that can learn functions similar to those that use handcrafted features with equal or better performance. This particular research will focus on the combination of this new knowledge and various methods to remove the complexity and difficulty of detecting forgeries with handcrafted features.

Objective 2b: Digital Image Forgery Detection

In addition to image splicing detection, UCCS is also involved in the research of digital image forgery detection by merging two of the specific techniques that are for detecting copy/move and splicing and applying that to an image to make a higher reliability of detection.

Objective 2c: Super Resolution of Photoactivatable Fluorescent

In established optics, the resolution achievable by optical instruments is limited by the effects of light diffraction at small scales. There has been a new technique discovered for super-resolving images using photoactivatable fluorescent proteins(PA-FP). However, these techniques perform well on low density proteins samples but have more difficulty resolving high density protein images. UCCS is involved in the research to super-resolve PA-FP samples using convolutional neural networks by combining super-resolution and localization techniques. The results for this research suggest a method for a wide array of situations with evaluation times much faster than existing methods.

Objective 2d: Image Segmentation

The purpose of UCCS current research of image segmentation is to improve some of the current methods of image segmentation which allows for more accurate results when categorizing images by combining various methods to create a robust algorithm. With the research, UCCS hopes to accumulate the results of a correlation between convolutional neural networks and categorizing images.

Objective 2e: Computer Vision

Some computer vision problems involve dense prediction that involve the labeling of images. In accordance with this problem is counting objects which involved enumerating the number of objects in given still image or video frame. Modern approaches to the counting problem involve the production of a density map however, objects in the image can occur at different scales which can make it difficult for a neural network to learn the proper density map. With that being said, UCCS is researching the use of dilated convolution as a simpler approach to the perspective-free counting problem.

Objective 3: Medical Image Analysis

Likewise to the second objective, when the main goal is completed, the third objective of UCCS students is to further advance image analysis but more specifically, medical image analysis. When an image is changed or converted so the meaningful information can be extracted, it is often used for medical purposes. For example, image analysis is used to study organs or tissues and in the diagnosis and treatment of diseases. To help in the research of medical image analysis, UCCS students are researching the following medical image analysis topics:

Objective 3a: Deep Image Segmentation(used for MRIs and tumors)

Currently, there is a problem of training convolutional neural networks for image segmentation tasks that involve unbalanced data. In the segmentation of MRI images, there is an imbalance of

pixels. For example, in a typical MRI image of a brain tumor, the volume of healthy brain tissue is significantly greater than the volume of cancerous tissue. UCCS is exploring alternative techniques intended to increase the accuracy of the model and neutralize misclassification arising from the unbalanced nature of MRIs.

Broader Impacts

Overview

One of the main benefits of getting the NVIDIA DGX-1 is to help teach our students and graduate students the core objectives of innovative deep-learning. With this knowledge, the students can then influence the university, community, and world to further research and develop topics of deep learning. Throughout their schooling career, students will be able to expand their knowledge of deep learning to have important technological experience to use in the work force.

Reaching Into the Community

With the education of deep learning, our students and staff will have the resources to reach out into the community to further teach and develop the topics of deep learning. Seeing as University of Colorado Colorado Springs is one of the only schools in southern Colorado acquiring a supercomputer with the capabilities of the NVIDIA DGX-1, it would be in the best benefit of the school and the community to share this piece of machinery. Allowing local colleges, high schools, and businesses access to the computer would also allow them the resources need to learn more about deep learning. For example, neighboring high schools could attend and hold summer camps at UCCS that would provide its students with knowledge involved in deep learning to help prepare the students for higher education or the work force. Businesses could also train their employees in deep learning topics such as Artificial Intelligence to help expand its business as the world is technologically advancing.

With the acquired resource of the NVIDIA DGX-1 deep learning environment, UCCS can help other schools in the area of all levels, as well as business reach the same goals of furthering the development and usage of deep learning topics. By reaching out into the community, neighboring institutions will have access to the supercomputer environment located at UCCS thus making the learning, teaching, and research of deep learning much easier. With this ability, UCCS and the neighboring community can work together to innovate deep learning and technologically advancing the field and themselves.

Global Impact

The University of Colorado will be using the NVIDIA DGX-1 to help teach our students deep learning but it will also be used for MRI medical imaging. Having a supercomputer for a deep learning environment, will allow the community and local hospitals access to improve upon the health of the community. Furthermore, with the research of natural language processing and image analysis, UCCS can not only locally progress our research, but we can be globally involved in the development of deep-learning research.

Timeline for Project

Spring 2018	The University of Colorado submits grant proposal to purchase NVIDIA-DGX1
Summer 2018	UCCS Computer Science Staff get hands on experience and familiarized with the NVIDIA-DGX1
Fall 2018	Implement deep learning research Medical/Non medical image analysis research using the NVIDIA-DGX1 begins NVIDIA-DGX1 is used to help UCCS in natural language processing
Spring 2019	Deep learning research picks up again. Continue to improve image analysis Continue using the NVIDIA-DGX1 for natural language processing.
Summer 2019	Teachers and staff collect and analyze the data and find ways to improve upon deep learning teaching at uccs The NVIDIA-DGX1 is made available to local community colleges and schools to help teach them about the deep learning process
Fall 2019	Deep learning research picks back up with more ways to improve and teach from previous semesters The NVIDIA-DGX1 is used to progress our understanding of natural language processing and to help with image analysis.
Spring 2020	NVIDIA-DGX1 is used to help teach deep learning at UCCS The NVIDIA-DGX1 is used to progress our understanding of natural language processing and to help with image analysis.
Summer 2020	Deep learning environment is open to high schools, companies and community colleges to use to teach more on deep learning. Uccs has a better understanding of using the the NVIDIA-DGX1 for image analysis and natural language processing. Offering more to the local community.
Fall 2020	Deep learning research picks up again. Continue to improve image analysis Continue using the NVIDIA-DGX1 for natural language processing.

Budget Justification

Chart 1:

	Item	Item Cost	Year 1	
			NSF Request 70 %	Cost Sharing 30%
1	DGX-1 with V100	\$149,000.00	\$104,300.00	\$44,700.00
2	DGX-1 with V100	\$149,000.00	\$104,300.00	\$44,700.00
Total		\$298,000.00	\$208,600.00	\$89,400.00

Justification: The main goal of UCCS is to buy two DGX-1 with V100 each priced \$149,000.00 for our students to support their needs for a deep-learning environment to research deep learning topics.

Instrumentation Specifics

Instrument Location: University of Colorado at Colorado Spring Campus

Instrument Code: MRI-31

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