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EGR/CS230
Computer Architecture and High-Tech Fundamentals
FINAL EXAM
Special Exam for Coronavirus

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On three separate pages, in 10-point Font, single-spaced single-column, and with the narrow margins set in this document, create two paragraphs on each page with each page addressing **any specific topic NOT specifically covered by your second midterm (computer system design), OR by the topic of your semester project.**

You may however expand on a topic about something that was a component of your second midterm computer system design that you did not do in-depth research on; for example, if you just considered a couple different kinds of RAM, you could pick RAM as one of the three topics to research in-depth as part of your final exam. Or if you picked microprocessor(s) for your 2nd midterm with a neural network in it, you could certainly research more on Neural Networks as long as you make sure you discuss in the first paragraph anything that we discussed anywhere in the course about neural networks; and then in the second paragraph find and discuss something entirely different from what was covered in the class lectures.

ON EACH OF THE THREE PAGES (**WITH A COMPLETELY SEPARATE TOPIC FOR EACH PAGE**):

1) In the **first paragraph**, summarize the most important aspects of whatever topic you have selected from the lectures. This will be graded on how well you very concisely and elegantly summarize this topic (as covered in the lectures) while making sure that you emphasize the most critical aspects of that topic (as discussed in lectures).

2) And then in the **second paragraph**, reference one very high-quality recent peer-reviewed citation that expands on the content that you learned in the course. Summarize in your own words the significance of the material that you have found. Put the citation in IEEE format at the bottom of the page, formatted just like you did for your semester project paper, in this IEEE Conference paper format: (http://users.etown.edu/w/wunderjt/IEEE_CONF_PAPER_FORMATTING.pdf). This will be graded on how novel and rigorous your expanded content is, and the quality of your citation including where it was published, who wrote it, and how recent it is.

Put your name at the top of this page,
and attach the three new pages to this document,

and rename it:

230FINALS20_*your-last-name***,***your-first-name***.PDF**

And email it to me BEFORE NOON ON FRIDAY MAY 8 of Finals week
(i.e., not on the scheduled may 4 at 2:30 PM timeslot for the final,
but rather four days later so that you have some time to work on it)

VR

Virtual reality headsets completely immerse the wearer into that virtual world. When most people think of VR, they think of video games. Instead of point-and-click games on the computer or third person games on consoles, VR puts the player in the action. They can see everything and interact with everything around them simply by moving their head around. VR is not just limited to gaming content. It can be used to tell the news. It can put the wearer into a poverty-stricken area, or an area in the midst of war and show the user what is going on and have them feel the impact for themselves, which is far more effective than having it be read by a news anchor. It can also be used to assist the justice system. Currently it is only experimental, but the theory is that virtual reality can be used to let detectives and jurors see and interact with crime scenes. I watch a lot of true crime shows and documentaries. From what I have watched, it is clearly difficult at times for jurors to fully comprehend the details of the crime scene, without interference from the lawyers on the case. VR can also be useful in practicing what to do when faced with a natural disaster. Researchers in Japan have designed a program that simulates the effects of a tsunami in order to have citizens know and understand the disaster and help them figure out the best course of action to save themselves and their loved in the event that another one would take place. VR can also assist in therapy. Especially now during the pandemic, the need for therapy is extreme. VR therapy can be a great way for patients to destress and talk about their needs and feelings without getting distracted by the environment around them.

Virtual reality can be used for a multitude of things in the medical field, including balance retraining, pain management, and rehabilitation for adults and children. Rehabilitation is a very tedious process that can vary in effectiveness depending on the patient's willingness to continue it. VR can help keep patients on track with rehabilitation and localize it. Depending on the patient's injury and location, finding a good physical therapy place can be difficult and at times impossible. With VR technology, the procedures that doctors prescribe and assist with can be done by machines almost anywhere. VR can help with the motivation by transporting patients somewhere that is not full of equipment and other people. Instead of making the patient feel like they are going through physical therapy, the VR technology can make it seem more exciting, more like a real life experience, like taking a walk on the beach rather than just walking on a treadmill. The technology can also be equipped to monitor the vitals of the patient while they are going through rehabilitation and determine the extent of their progress [1].

References

[1] Tohru Kiryu, "Sensationn of presence and cybersickness in applications of virtual reality for advanced rehabilitation," *Journal of NeuroEngineering and Rehabilitation* vol 4, 34, 2007.

Color

RGB color is used a lot in the computer world. It is used for aesthetic purposes, specifically in gaming consoles. But it is also necessary for monitors to display colored images. Different colors are made up of wavelengths of different sizes. For example, we see short wavelengths of light as blue and long wavelengths of light as red. RGB is used as a spectrum for the colors that we see. They are considered the primary colors of the visible light spectrum, which of course is different from the primary colors of the rainbow. Typically, the colors are arranged in color wheel where red, green, and blue make up one triangle and cyan, magenta, and yellow make up another triangle inside the circle. CMY is known as the secondary colors in the visible color spectrum since those colors can be created through mixing the primary colors. Computer monitors use RGB color spectrum to display colored images. Each pixel on the monitor is illuminated to the point that it gives off a different color. They all start off black; when one pixel has all RGB phosphors on, then it will display white. That is called additive color. Additive color is used in all devices that can take pictures, like digital cameras and video cameras. Subtractive color is when color is created by taking away wavelengths of color. This method is used in magazines and photographs. The object typically starts off as white, when all of the RGB color spectrum is turned on. From there, colorants like dyes are added to subtract some of the white to reveal the intended color. Subtractive color utilizes the CMY color spectrum; it also uses black, which is labeled with a K to avoid confusion with blue. When all the CMY colors are turned on in equal amounts, the result is a pure shade of black. The way a monitor or TV screen displays color is typically via a plasma display panel. The mercury inside the system is vaporized and a high voltage runs across the cells. Those volts run through the plasma and hit the mercury particles and increases the energy in them. The excess mercury energy is released as ultraviolet (UV) photons, which hit the phosphor atoms, which raises their energy levels. The excess energy in the phosphor atoms is released as the colors on the RGB spectrum. The colors shift depending on how much energy is released from the phosphor atoms.

Computerized images are affected by noises such as Gaussian noise. To avoid the effects of the noise on the image, it must go through a filtering process. Gaussian noise speckles the image with RGB pixels in places they should not be, and in colors that do not match the rest of the image. The RGB image goes through a linear spatial filter and follows about three steps. First, the three component images should be extracted. Then, after each image is individually extracted, smooth out the red component in the image. Finally, reconstruct the filtered RGB images; the result will be the fixed, smoother, and more correct looking image. There are three popular filters that go through this process: the average filter, the median filter, and the adaptive median filter. The average filter replaces each pixel by the average of the pixels that are in a square around it. The median filter does the same except with the median or weighted average instead of the average of the pixels surrounding it. The adaptive median filter goes through and determines which pixels are individually affected by the noise and attempts to smooth out only those pixels using the median filter method [1].

References

[1] Jihad Nader, Ziad Alqadi, Bilal Zahran, “Analysis of color image filtering methods,” *International Journal of Computer Applications* vol 174, 8, September 2017.

Cache

There are four types of cache that we learned in this class, memory cache, internet browser cache, disk caching, and the cache server, though we focused mainly on memory cache for the purposes of the class. Memory cache is a part of static RAM (SRAM) and is used to store data and instructions that are commonly used. Because most programs use the same instructions over and over, it is more efficient to keep as much of that information and data in the SRAM to avoid using the DRAM, since that slows down the computer. The memory cache utilizes temporal and spatial locality of reference. Temporal locality of reference is the process of holding data that was recently used close by, since there is a high probability that the program is going to need access to it in the future. Since the data is held there, it is easy to take that information quickly and keep the program running efficiently. Spatial locality of reference is when data is held in cache blocks. When the computer needs some data, a block is searched through to try to find the line of information. It will also queue up another cache block, since there is a probability that that other block may contain the necessary data for the program and will possibly be searched as well. The internet browser cache is utilized when browsing the internet, as the name suggests. This cache holds the web page that was most recently opened. If the page needs to be reloaded, the computer takes the page and all its contents from the cache on the hard drive, where it was being temporarily stored. It is efficient and keeps the computer running quickly instead of having to wait to load all content that is on the web page multiple times. Disk caching is like memory caching in many ways, the main difference being that memory caching is in SRAM, and disk caching in the main memory. Like a memory cache, a disk cache will hold the most recently accessed data. When the computer needs some of that data, it will first check the disk cache to see if it is in there. Disk caching is far more efficient in searching for something by using RAM. The alternative would be searching the hard drive, which would take much more time. Lastly, the cache server is meant to store web pages that were recently looked up by the user of the computer. This is how the history and "back" button on Google Chrome work. The most recent web browsers that were searched are stored in this cache and if any user wants to refresh one of those pages, the computer will look through the stored browsers to see if it is in there. If it is, then the computer will put out the stored version of the webpage instead of attempting to download the page and contents again.

It was mentioned briefly in the article in the textbook, but there are three main levels of cache, conveniently name L1, L2, and L3. L1 is the fastest and the one closest to the processor. In a multiprocessor machine, there is a separate L1 cache on every processor. The L1 usually has a size of 256 KB but can be up to 1 MB depending on the processor. L2 is generally bigger than L1 but is slower. The size of L2 can get up to 8 MB. L2 cache keeps the data that has a high chance of being accessed by the computer. Each core in a multicore system has its own L2 cache. L3 is the largest and slowest cache of the three levels; the L3 cache can reach up to 50 MB. The caches are equipped with a cache controller. It processes the requests of data and the transfer of data between Cache and Processor and Cache and Memory. The processor requests some data and the cache controller checks to see if it is in the cache. If it is there, it will send it to the processor; if not, the controller sends a request for that data from the memory. Cache controllers divides each data request into three parts: tag, set index, and data index. The set index is used to locate the line of cache memory where the data requested may be. If the line is represented as active, the tag is compared. If there is a success in both cases, the element is fetched and is labeled as a Cache Hit; if not, it is labeled a Cache Miss and the data is requested from memory. When a Cache Hit happens, the time it takes to process the request and return the data is known as the Time to Hit. When a Cache Miss happens, it takes time for the data to come out of the memory; that is called the Miss Penalty. There are two main data writing methods: the write-back and the write-through. In write-back the value being updated does not update the cache and memory at the same time; the cache is updated first and occurs when the update bit is set to 1. In write-through the value update simultaneously in the cache and memory; this makes the write functions slower than those in the write-back. To measure and compare cache performances, the Average Memory Access Time is calculated using the formula:

$$AMAT = Hit\ Time + Miss\ Rate\ x\ Miss\ Penalty$$

The best caches have a low AMAT measurement, so the best way to enhance the performance of a cache is to reduce the Miss Rate, Miss Penalty, and the Hit Time, as evidenced by the equation [1].

References

[1] Ameer Khan, "Brief overview of cache memory," Ameer Khan Research & Development Center, Pakistan.