Final Report of problem situation

Alan Rodrigo Vega Reza A01750658
Fernanda Ponce Maciel A01799293

Modeling of Minimum Systems and Computational Architectures
(Gpo 201)

Thursday October 19, 2023

Automotive Industry problems that could be solved with electronics

The automotive industry faces a bunch of different problems that are mostly inherent to the fact that the automobile has existed for more than 100 years, while the automobile has evolved throughout the years, one of the main areas in which consumer cars have evolved is security and user experience, there are a couple of objectives that car manufacturers have had as their main goals with their cars, usually regarding fuel efficiency, and ease of drive, little by little, there has been more and more driver aids with the objective of making cars easier to drive, an example of this is ABS, traction control, as well as other aids with the purpose of making cars safer and easier to drive. However, there are still a lot of things that could be done in order to improve them with electronics.

The ones that we consider the most interesting are.

Driving Assistances: There are a lot of assistances that could be used in order to make the cars safer, and more comfortable, some of these are:

- *Lane departure assistance*
- *Blind spot alerts*
- *Automatic parking*
- *Automatic braking*
- *Assisted braking*
- *Assisted steering*

The general idea is to use different sensors, such as proximity, LiDAR, radars and different cameras for the ECU to be able to understand what's happening around it and aid the driver with different electronic systems that have the perfect response for whatever situation.

The variables would be the data, be it images, video footage, heatmaps, etc. the different sensors of the car, the cameras, and the mapping with radar, this information could be analyzed by the cars computer in real time and using vector calculations, for example in the case of the lane departure assistance, the computer would be able to calculate possible collisions, other instance would be with the assisted breaking, where the car could "know" the speed at which the car is going and apply enough pressure on the brakes for a safe braking within the distance with another car or some other object.

By wire systems: Continuing with the driver aids, by wire system refers to a system where there is no actual mechanical connection between the car systems and the control systems in the cabin, instead, everything is connected via electronics and this allows for a much more customizable experience, for example, with the steering wheel, it could have a different set of angles at different speeds so that the driver doesn't have to turn the steering wheel all the way in order to be able to turn at low speeds but still would be able to make small adjustments at high speeds with a bigger turn radius, these could also be customized by the user so that their steering wheel is completely comfortable to them, then if maybe someone else in their household wants to use the car they could also have a steering profile and have a comfortable experience as well, other examples of this include brake control, throttle control and shift by wire.

The variables involved would be the position of the steering wheel, the position of the wheels and the desired turn radius and angle of the wheels, as well as the speed of the vehicle. The position of the steering wheel could be measured with sensors and then depending on the position and the profile, the computer could determine the amount of angle that the front wheels should have, there could be another sensor in the front wheels to make sure that the angle is correct and also it would be necessary to send speed information to a computer in order to change gradually the radius of the steering wheel.

How these variables are present in other industries

Images being collected by cameras, proximity sensors, radar information, LiDAR:

These variables are used mostly in the aviation industry, as well as the naval industry, particularly in the military sectors in order to be able to detect enemy planes and/or ships, also it is present in missiles and they use them in order to track their objectives in order to secure a hit.

Position of the steering wheel, position of the front wheels, speed:

These variables are quite particular, however an example of by wire systems can be found in fighter jets, in order tom make them less prone to failure, the control systems are all fly by wire, these systems make the plane better at resisting damage since there are no exposed mechanical parts that can be damaged easily by enemy fire.

Cyber Physical Systems and the Von-Neumann machine

The von Neumann machine, designed by John von Neumann and his colleagues, is the foundational design of the modern computer. In their 1946 paper, "Preliminary Discussion of the Logical Design of an Electronic Computing Instrument," they established key principles, such as keeping data and instructions in a single memory and encoding instructions to be modifiable by others. This innovation enabled the development of high-level programming languages and significant advances in software. Additionally, it solved the problem of rapid access to instructions, which ENIAC had faced with its plugboards, paving the way for computers with stored programs, known as von Neumann machines. However, this approach required more memory than ENIAC.

The automotive industry is slowly changing, these innovations, and the advent of computers of cars has gone a long way in turning cars from purely mechanical systems into Cyber-Physical Systems (CPS), these systems are made by the combination of the mechanical systems of the car, such as the engine, the brakes, the throttle, etc. the sensors and actuators that transmit everything to the ECU hardware and the CPS software which takes all the information and processes it in order for the car to actually work as intended. The ECU in cars is usually a Von-Neumann machine that works closely with the sensors and the mechanical systems in order to control the car.

1) Taking as reference the architecture shown in the Microchip PIC18F4550 specification sheet, determine the following:

Maximum word size that the device can emulate, in the creation of a minimum computing system (opcode + address). Remembering that opcode defines an operation code and address a memory address. The maximum word size is 16 bits, with an 8-bit opcode and an 8-bit address

Maximum number of instructions or operations that can be executed within the device (program memory). 16384

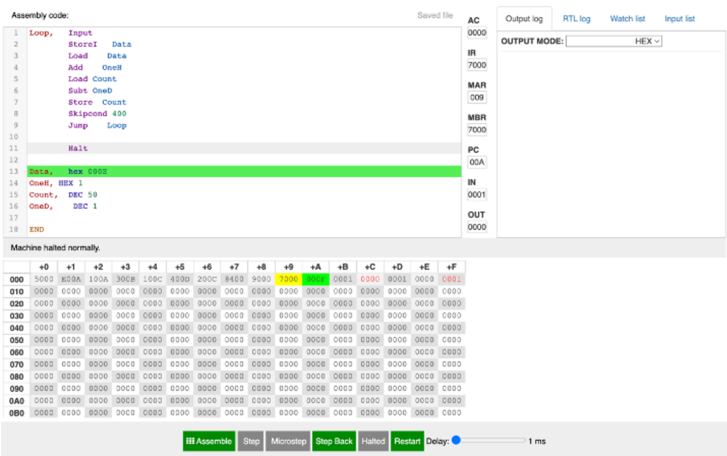
Maximum operating frequency of the device: 48 MHz

Average power consumption: 5.5V

2) Compare each item from the previous point with at least 1 processor used in the automotive industry for the engine control unit (ECU)

Category	Microchip PIC18F4550	MC9S12XDP512
Maximum word size	16 bits	16 bits
Maximum number of instructions	16384	16384
Maximum operating frequency	48 MHz	80MHz
Average power consumption	5.5V	2.5V

3) Taking as a reference a sensor that delivers a reading through a parallel bus at a rate of 12 bits / ms, carry out a program within the MARIE environment that stores the first 50 measurements in memory.
https://youtu.be/MmVfrKumDmQ



4) Determine the size of the program to read the sensor and store the information in memory.
50 bits of stored data
15 bits of instructions
65 * 16 = 1040 bits

5) Observe and indicate the differences that exist between the processors used in real life (automotive industry) and the processor used in solving the problem situation.

The PIC18F4550 and MC9S12XDP512 are both microcontrollers commonly used in different applications within the automotive industry and problem-solving situations. Let's compare these two processors in terms of their features and use cases.

1. Documentation:
   While the documentation for the PIC18F4550 was little more than a hundred pages of information, the documentation for the MC9S12XDP512 is more than a thousand pages long.
2. Architecture:
   -PIC18F4550: It uses the Harvard architecture with an 8-bit RISC core.
   -MC9S12XDP512: It uses the modified Harvard architecture with a 16-bit CPU core.
3. Bit Width:
   - PIC18F4550: 8-bit microcontroller.
   - MC9S12XDP512: 16-bit microcontroller.
4. CPU Speed:
   - PIC18F4550: Typically operates at a clock speed of up to 48 MHz.
   - MC9S12XDP512: Typically operates at a clock speed of up to 25 MHz.
5. Memory:
   - PIC18F4550: It has 32 KB of flash memory for program storage and 2 KB of RAM.
   - MC9S12XDP512: It has 512 KB of flash memory for program storage and 51 KB of RAM.
6. Peripherals and Interfaces:
   PIC18F4550: It features a USB 2.0 interface, multiple GPIO pins, and a variety of communication interfaces such as SPI, I2C, UART.
   - MC9S12XDP512: It offers a wide range of peripheral modules, including CAN (Controller Area Network), multiple timers, ADC (Analog-to-Digital Converter), and more.
7. Use Cases:
   - PIC18F4550: Suitable for simpler applications, including basic sensor interfacing, LED control, and simple automation tasks.
   - MC9S12XDP512: Designed for more complex automotive applications, such as engine control units (ECUs), body control modules, and other safety-critical systems in vehicles.
8. Automotive Industry:

In summary, the PIC18F4550 and MC9S12XDP512 differ in terms of architecture, bit width, CPU speed, memory capacity, and peripheral features. While both can be used in the automotive industry, the MC9S12XDP512 is better suited for more demanding applications due to its higher computational capabilities and advanced peripherals. The choice between these microcontrollers would depend on the specific requirements of the automotive application or problem-solving situation at hand.

Final Reflection

The automotive industry has historically been known for its innovation in manufacturing and engineering. However, the advent of digital transformation has brought about profound changes in the way this industry operates. This reflection aims to explore the multifaceted impact of digital transformation on the automotive sector.
Digital transformation has revolutionized manufacturing processes in the automotive industry. Smart factories, automation, and the Internet of Things (IoT) have improved production efficiency, reduced errors, and lowered operational costs (Smith, 2020). The use of digital twins has allowed for real-time monitoring and predictive maintenance, minimizing downtime (Johnson et al., 2019).
The automotive industry is also using digital transformation to enhance environmental sustainability. Electric vehicle (EV) development, battery management systems, and energy-efficient manufacturing processes are supported by digital technologies (Brown et al., 2020). These innovations contribute to reducing the industry's carbon footprint.
Despite the numerous benefits, digital transformation in the automotive industry comes with challenges such as cybersecurity threats, data privacy concerns, and the need for a skilled workforce (Johnson, 2021). Overcoming these challenges is crucial for the continued success of the industry's digital transformation journey.
Digital transformation has had a profound impact on the automotive industry, affecting manufacturing, product development, customer experience, supply chain, safety, environmental sustainability, and more. The industry has embraced digital technologies to innovate and remain competitive but it must address associated challenges for sustainable growth.

Link to the video with the code:

https://www.youtube.com/watch?v=CSUhlMEuMB4

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