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PSA memory optimization method for heartbeat and EMG monitoring for prosthetics

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ABSTRACT:

The field of medical science is highly dependent on the modern embedded devices to assist in the monitoring of the patients. To have efficient monitoring devices in the medical field for any body part, the device needs to efficient in terms of energy and runtime. Futuristic prosthetic limbs will also need monitoring by embedded devices for accurate measurement of parameters for the movement of the prosthetic limbs. In order to achieve that, in this paper we have proposed a memory optimization method for a device which uses the heartbeat and EMG sensor to be used as monitoring equipment for prosthetic limbs. It is important the devices controlling the prosthetic limb is efficient in term if memory usage and energy consumption. The PSA mechanism is based on Prioritization, Scheduling and allocation of the memory units in the algorithm governing the device. The proposed PSA method shows improvement in the performance of the embedded system when tested during the experiments in the performance parameters of energy consumption and the time consumed to run a cycle of algorithm.

Keywords: *energy consumption, embedded system, Futuristic prosthetic, sensor*

1. INTRODUCTION

1.1 Memory optimization

Memory optimization can be defined as the resourceful utilization of the available memory in order to improve the performance of the embedded systems. Memory optimization in embedded systems is one of most important needs in modern embedded system devices embedded system because it improves the with more energy efficiency and reduction in the runtime of the code on embedded devices [1]. The optimization of embedded system either from the hardware side or from software side makes significant strides toward the completion of the goal of high energy efficiency and reduced run time. Many techniques and ideas have been proposed to optimize the embedded systems in hardware and software directions including methods of proposed architectural improvements and mixed approaches to optimize the system [2]. High energy efficiency and reduced run time are the parameters which are required for the improved working of the embedded system. To achieve these parameters, our proposed method changes the way we handle the data during the runtime of the code [3]. This approach can be categorized as an improvement from the software side. In this approach, by controlling the data flow and temporary memory allocation of various data elements during the runtime, it will evolve as indispensable improvement in energy and runtime [4]. The proposed PSA method as discussed in detail in the later sections of this manuscript uses prioritization, scheduling and allocation in a smart way to achieve the desired improvements in the system. The overall approach of the work done is to design a device with a heartbeat sensor and an EMG sensor equipped with the proposed memory optimization method for future uses to operate prosthetic limbs [5]. The proposed system includes the above mentioned sensors and an AVR microcontroller which is tested with both the codes, i.e. for the

code which is not optimized and the code which is optimized with PSA. Results confirm that the PSA memory optimization method is improving the results by a significant margin.

Embedded systems are specifically designed to implement the objective circuit designs. Objective circuit designs are the specific purpose circuit design unlike the general purpose circuit designs used in general purpose computers. While making the system, it has to be kept in mind that the system is energy efficient because in most cases the system is wireless. It is designed as a wireless system, to allow the system to be mobile and portable which is one of prime requirements. Moreover due to the fact it is mobile, the embedded circuits used in it are required to be made small in size which requires smallest possible battery units and memory units. These requirements kindle the need of memory optimization in embedded systems which can be done via many methods and technique like efficient programming and efficient allocation of memory on the software side and using faster memory chips on the hardware side. In this research, we are focusing on the software side of memory optimization using the proposed method given in [6] another work. That technique comprised of Prioritizing, Scheduling and Allocation which can be termed as PSA memory optimization. Some of the components which were used in the work are introduced below and the rest of the paper has literature review, proposed working of the PSA memory optimization method and results of the experimentation.

1.2 Electromyography

By testing the electromyography (EMG), estimation of muscle action has been utilized in medicinal research. In the case of the presence of increasingly more dominant smaller scale controller and the coordinated circuit, the electromyography sensors can be utilized in a wide range of control framework. As EMG movement (estimated in smaller scale volts) is straightly identified with the measure of muscle withdrawal just as the quantity of contracted muscles – or as such, the more grounded the muscle compression and the higher the quantity of actuated muscles, the higher the recorded voltage amplitude will be. As EMG action is even quantifiable when we don't show clear activities or even hinder certain practices, EMG records speak to an extra source of data into psychological conduct preparing a new way of study [7].

1.3 Heartbeat sensing

Heartbeat Sensor is a minimal effort, extremely little size an attachment and-play pulse sensor for Arduino and Arduino boards [8]. It can be utilized by craftsmen, competitors, creators, and game and portable engineers who need to effectively fuse live pulse information into their activities. Heartbeat Sensor Amped includes intensification and commotion dropping hardware to the equipment. It's detectably quicker and simpler to get dependable heartbeat readings. Heartbeat Sensor works with either a 3V or 5V Arduin

1.4 Prosthetics

Since the prosthetic are there to help in the movement of artificial limbs in a person, the device which will control the prosthetic limbs needs to be fast enough to detect the muscular movement and react to it [9]. The need of embedded systems which are fast enough can be fulfilled by designing systems in such a way in which they are memory optimized for using the memory in a better manner, which will contribute in making the system more efficient.

2. LITERATURE SURVEY

Stefan et. al. presented new improvements [10] in DXmem library. The main contribution of the work in this direction is the new optimizations and evaluations. This consists of a system improved in address interchange which is faster now as compared to the older version.

Saruet. al. proposed [11] a method of prevention for unnecessary authentication of the request during run time. The system in its simulation outperformed many other state of the art methods in its league. The system served the application with a smaller size of the memory as cache and did not compromise the performance.

Qi et. al. presented [12] a system for the optimization of the memory in large scale inference algorithms. To help out in that SRAM are used for the purpose of helping the minimization of DRAM access. Current accelerators are working well but have filed to reduce the access of DRAM and SRAM. This work proposes a memory driven accelerator for large scale applications for faster access of the memory.

Fatih proposed [13] a new memory system for the embedded devices. Several memory ideas have been deployed to close the gap between the memory systems. This work will analyze the new proposed solutions in the field of memory optimization. No solution is a universal one, but there is a solution to every memory problem which is specialized for it.

Arnaud proposed [14] a new system for the use of the device memory. New evolving concepts in the field of embedded memory optimization are to be considered and their impact on the power performance of the devices is also to be measured and optimized if we want to create systems that are power efficient from the energy consumption point of view. Particularly the proposed STT – MRAM technology has a lot of potential to reduce energy if cache memory.

Taewhanet. al. presents [15] that in many embedded frameworks, especially those with high information calculations, the rearrangement of memory access is one of the real bottlenecks in the framework's exhibition. In particular, the proposed methodology, called memory-access-code optimization (MACCESS-select), takes care of the three issues at the same time: 1) assurance of recollections; 2) mapping of clusters to recollections; and 3) booking of memory-get to activities.

Inhyeet. al. presented [16] a software based optimization method for improvement in the performance of the software for the circuit devices in the communication field. The levels of optimization are applied to the systems in embedded to see the work analogy of it in terms of efficient energy performance. A 12% increase, a 72% decrease and a 35% decrease in performance of software, memory access and memory usage we observed respectively.

3. PROPOSED WORK AND EXPERIMENTAL SETUP

The proposed work uses the methods based on the Prioritizing, Scheduling and Allocation of the memory as discussed earlier. The proposed work utilizes the PSA (Prioritizing, Scheduling and Allocation) method for optimizing the memory of a device equipped with heartbeat and EMG sensor. In this work several chronological steps were followed which enable to generates the expected results. The first step was the literature review and making the device capable of monitoring the heartbeat and muscular movement via EMG embedded in the device.

Second step was to optimize the software according to the PSA memory optimization method. Third step was to note the execution time and the computational efficiency of the software on the device. Lastly the results of execution time and computational efficiency are to be compared.

3.1 The device used in the study

The device used in the study is an embedded device which is equipped with the heartbeat sensor and an EMG sensor which are used measure the heartbeat and the muscle movement of the person assuming the prosthetic are to be controlled by monitoring results of the device itself. The device has a LCD display to show the information. The device is run by an AVR microcontroller which serially controls the signal inputs from both sensing equipment in the device.

3.2 Optimization of the code

The code with which the embedded device is governed is to be optimized using the PSA memory optimization method for better management and use of the memory. PSA method as mentioned before is made up of main three parts which are P – Prioritization, S – Scheduling and A – Allocation.

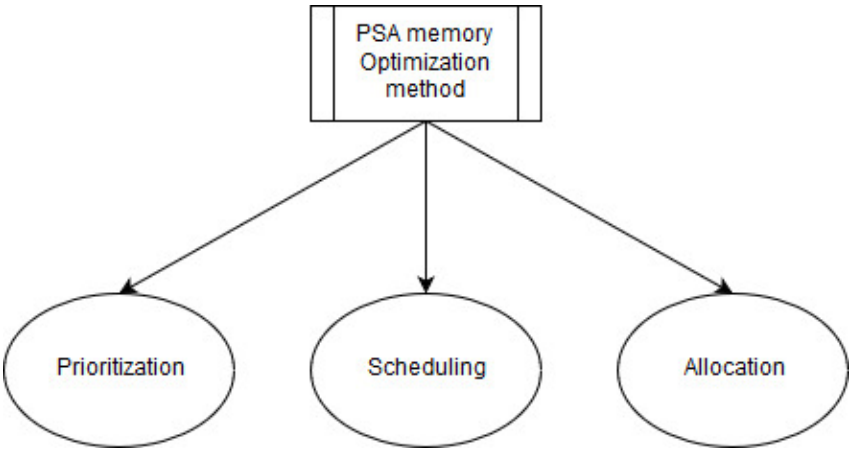

Fig 1: PSA memory optimization components

The code which is to be used for the optimization has several components. For any program *P1* the project includes many sets of storage objects called *SO (P1)* which are given as *equation 1*

$$SO(P1) = SO(P1)_1 + SO(P1)_2 + OS(P1)_3 + \ldots\ldots\ldots SO(P1)_n \quad (1)$$

a. Prioritization

In prioritization the components of the code are prioritized according to the frequency of usage and the time it takes for execute the usage of that particular component. The calculation of the scheduling priority is done as *equation 2*

$$SPR_i(SO_i) = \frac{F(SO_i)}{T} \quad (2)$$

Where T is time and F is the frequency of usage of the storage object.

b. Scheduling

Scheduling object status is generated as the ascending or the descending number in the storage space and exact object requirement sequence given as equation 3

$$SST_i = X_q \quad (3)$$

Where X is storage object and q is the sequence.

c. Allocation

The memory allotment is according to the scheduled components. Allocation of less prior components far from start location causes less time delay in the execution of the code.

3.3 Significance of PSA method

The significance of the PSA method is that by the use of prioritization, Scheduling and Allocation the program uses less memory space at any given time because of the memory saving and management objectives of operations which are carried out in PSA method. As the memory use and management improves the execution time and the computational efficiency are bound to reduce which we shall see in the next sections.

3.4 Pseudo code

1: ***Input C=Code;*** *// the code which is prepared for the device microcontroller is taken as input to be optimized.*
2: ***F=Procedure*** *GET FREQUENCY (C)// this function calculates the number of times an instruction is used and the number of times a variable is used for the calculation.*
3: ***end Procedure***
4: ***T = Procedure*** *GET TIME CONSUMED (C) // this function calculates the amount of time needed for the execution of the instructions.*
5: ***end procedure***
6: ***P=F/T; // P is Priority;*** *//priority of a variable or an instruction is calculated by ratio of its frequency and time consumed*
7: ***S=Procedure*** *SETASCENDDESCEND (C) // this function aligns the instruction in the memory by its priority, either in ascending or descending order (we will be using ascending order for optimization).*
8: ***end Procedure***
9: ***A=Procedure*** *SETALLOCATION (C) // this function allocates the memory near or far for the compiler in ascending order in which the most used instruction or variable in closest registers. Also, it releases the variable when they are no more needed.*
10: ***end Procedure***
11: ***OC=Procedure APPLYPSA (P, S, A)*** *// function applies all the changes to the code.*
12: ***end procedure***
12: Output C'=OC; *// optimized code is the output of this procedure.*

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4 RESULTS

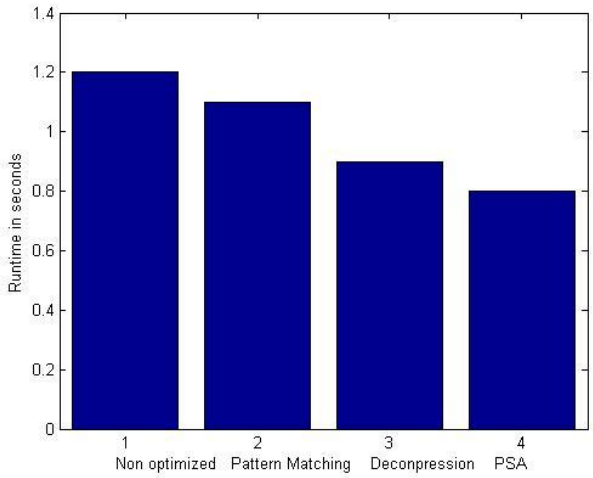

Fig 2: Runtime comparison

Fig 2 shows the runtime comparison between the non-optimized codes, Pattern matching, Decompression and the PSA optimized code. The bar graph shows the performance of the PSA optimized code to better because it has 0.8 seconds in comparison with 1.2 seconds of runtime of non optimized code.

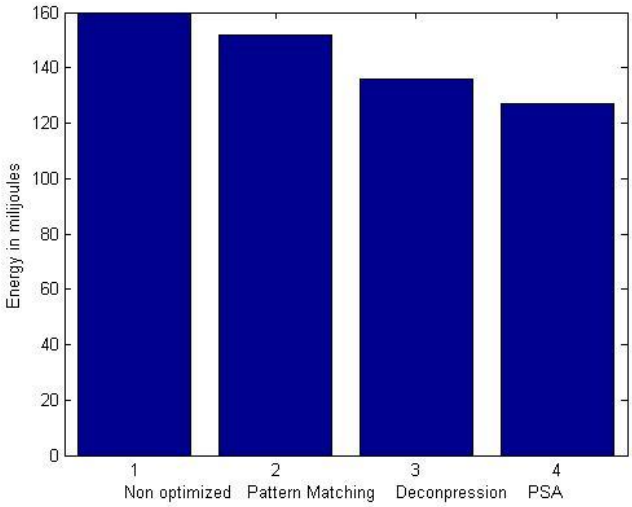

Fig 3: Energy consumed comparison

Fig 3 shows the energy consumed comparison between the non-optimized codes, Pattern matching, Decompression and the PSA optimized code. The bar graph shows the performance of the PSA optimized code to better because it has 127 milijoules in comparison with 160 milijoules of energy consumed of non optimized code.

5 CONCLUSION

We have presented a work which tries to optimize the use of memory in embedded system using the proposed PSA method of memory optimization. In the due course of this work we firstly had to finalize the objective device on the experiments were going to take place, which was finalized a monitoring devices with heartbeat and EMG sensors. After that the PSA algorithm was formulated using inspiration from a previous work [1]. After the hardware and software, the two essential components were ready the experiment of different codes on the hardware device were performed. One time with the code which was not memory optimized and once with the optimized code. The results showed that the performance of the memory improved code is better in terms of energy consumption i.e. it has less energy consumption and the also better in the runtime i.e. it has less runtime for the same objective.

In the current work that is done, the testing of the device with the EMG and the heartbeat sensor is done for being more efficient than the existing algorithm. In the future work, the use of this PSA algorithm for actually controlling the human prosthetic equipment is intended to access the real time utilization and then optimization of the set algorithm in the world.

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