UKRAINIAN CATHOLIC UNIVERSITY

BACHELOR THESIS

4-wheel stroller with smart emergency brakes system

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A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Science

in the

Department of Computer Sciences
Faculty of Applied Sciences

Lviv 2020

Declaration of Authorship

I, Yuliya ANTONYSHYN, declare that this thesis titled, "4-wheel stroller with smart emergency brakes system" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

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4-wheel stroller with smart emergency brakes system

by Yuliya ANTONYSHYN

Abstract

This work is about inventing smart control system and better mobility system for baby's strollers and wheelchairs. The carriages based on a microcontroller helps reduce the applied force for people driving them. And based on off-road vehicles canones chassi is a worthy opponent of poor road coverage. Also smart brakes are great confidence for caretakers in safety on hilly terrain.

Acknowledgements

I want to say thank you to my husband who supported me with coffee and snacks during my "working hours" and helped me with all the mechanical engineering. To my son who was the inspiration and the main disorganisation of the process. I want to say thank you to my parents for all the calming down words. I want to say thank you to Oleg Farenyuk for answering all of the questions. I want to say thank you to Kostyantyn from Move.one.design and Serhii from ElectricBikes for all the clarifications about motor-wheels. I want to say thank you to Markiyan from SoftServe robotics department. Also I want to say thank you to the university which gave me the perfect opportunity to start this project and LvBS to their courses that helped me with business part organisation...

Contents

List of Figures

List of Abbreviations

MCU	**M**icro**C**ontroller **U**nit
BMC	**B**usiness **M**odel **C**anvas
SWOT	**S**trengths **W**eaknesses **O**pportunities **T**hreats
BLDC	**B**rushless **D**irect **C**urrent **M**otor
BMS	**B**attery **M**anagenment **S**ystem
LiFePO4	**Li**tium **Fe**rro **P**hosphate
SOC	**S**tate **O**f **C**harge
PID	**P**roportional-**I**ntegral-**D**erivative
ABS	**A**nti-lock **B**raking **S**ystem
PWM	**P**ulse **W**idth **M**odulation
ESC	**E**lectric **S**peed **C**ontroller
PWM	**P**ulse **W**idth **M**odulation

Dedicated to my son…

1 Introduction

1.1 Relevance of the topic

Every parent wants the best for his child. Therefore, they start the most interesting process – choosing baby strollers even before baby's birth. The hardest moment is to decide which company and which stroller model to buy and how much it is going to cost. Nowadays the market is oversaturated with the number of different models represented for almost every wallet. The price range is truly wide. You can buy a stroller from a hundred to almost 7 thousand dollars. But what is the real difference between those besides brand promotion? Is this just a good marketing strategy?

As I can say from my own experience and market analysis, I did – there is No big difference, but little things as tactile material, lining material, one or another assembly system, chassis material, wheels size, bag size, weight, cup holder, and so on. Almost none of these characteristics affects real usage, ride performance, and wear resistance.

Most of the young parents and low-mobility people from post-Soviet countries have one problem in common - sidewalks quality. Pits on roads, cracks on tiles, crocked pavement, and the worst asphalt – all of that is an integral component of our everyday life. Unfortunately, barrier-free environment is an unreachable urbanist's dream in Ukraine so far.

Years ago, babytech was considered a niche market that few investors understood or wanted to get into. Today, anyone considering adding to their family can find technology for everything from fertility to potty training and beyond. [5] Recently, investors in the United States have invested half a billion dollars in the industry.

1.2 Goal

The goal is to develop a complex smart stroller system and enter the market with this product, which not yet occupied by such devices. Combine modern technologies and further integrate them into our daily lives. Such as: a function of assistance on a hill, emergency braking system in case of control loss, automatic swinging function with a smart proximity sensors system, gadget charging function from the trolley, soft and long-range independent suspension and a battery charge indication system.

2 Business

Since I am developing a complete product, not an algorithm or software separately, I would like to start with the business part.

Perhaps the most important part of the project is understanding whether your product is needed on the market or not, what features are going to be in demand for end-user, and whether it is worth starting this project at all. Because for me any project including diploma automatically should be something practical for everyday life and can become profitable in the nearest future.

Further, in this paper by the word "project", I mean the baby trolley because I am keen on this topic, and the niche is not competitive yet. When some of the features are already applied to wheelchairs, however, any systems I have developed can also be applied to the last ones.

The best way to start the analysis is to identify the target audience, its needs, pains, and how to solve them.

2.1 Buyer personas

To understand my target audience, I will use buyer personas(user personas). User Personas represent real, living, and breathing people who will engage with my product, their characteristics.[7] The perfect number of those is 3-5. All of the personas should be as different as possible but still interested in product to create clear Target Audience.

A target audience is the demographic of people most likely to be interested in your product or service.[6]

Masha

Personal Background

age: 24
family: married
kids: waiting 1st
education: bachelor in marketing

Property

phone: the newest iphone
income: blog
car: smart
live: apartment in new high-rise building
animal: cat

Timespending

social media: instagram, netflix
likes: books about personal grows
preferences: soy-free cappuccino with avocado toasts
places: coffeeshops, cheese bakeries
watch: popular series
babysitter: her mom and sis

Borys

Personal Background

age: 29
family: married
kids: planning 2nd
education: college

Property

phone: iphone 8+
income: wedding photographer
car: old Cherokee
live: loft appartment center
animal: haski

Timespending

social media: instagram, netflix, facebook, behance, youtube, twitter, pinterest
likes: mountains, yoga, personal courses, traveler
preferences: food delivery
places: coworking, bars
watch: popular series, movies online
babysitter: him and his wife

FIGURE 2.1: User Personas Masha and Borys

Peter

Personal Background

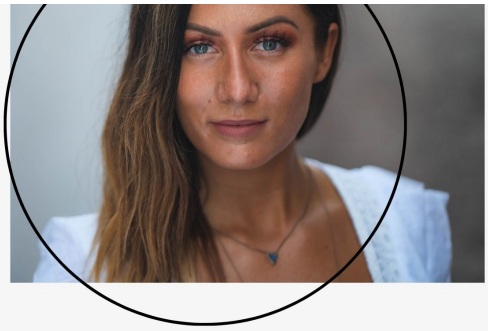
age: 45
family: married
kids: waiting 2nd
education: master degree in business

Property

phone: new Samsung
income: own a restaurant
car: Mercedes C-class
live: Big house near city center with big garage
animal: 2 golden retrievers

Timespending

social media: Facebook, gmail, Viber
likes: comfort and quality
preferences: restaurant food, old whiskey
places: gym, restaurant
watch: news, series in original lang
babysitter: agency



Natalia

Personal Background

age: 38
family: married
kids: waiting 3rd
education: doctor

Property

phone: new Iphone
income: cosmetologist
car: taxi
live: Big apartment near forest
animal: Yorkshire terrier

Timespending

social media: Facebook, Viber
likes: courses for cosmetologists, congresses
preferences: keto-dieting, farm food
places: gym, theatre
watch: TV shows
babysitter: granny

FIGURE 2.2: User personas Peter and Natalia

2.2 User stories

User stories are a great method for expressing stakeholder requirements. [13]

- As a user, I want to travel with my child to the mountains and forests and I want the stroller to have a good suspension that the stroller does not shake on rocks.
- As a user, I want have free hands while lull my baby, because it takes a long time for my daughter to fall asleep. so I would like the stroller to do that itself.
- As a user, I want the stroller to speed up so I can put less effort.
- As a user I want to see the battery state of charge to ride safely and know when to charge it.
- As a user, I want to sit on a bench and read a book, or follow friends on Instagram, so I want the stroller to take care of the child, swing it, but be careful not to crash into something.
- As a user, I live in an area far from the downtown, and when I walk with a child I have to walk on pits and destroyed sidewalks, so I want the stroller to cope well with these inequalities.
- As a user, I have problems with epilepsy, and there have been cases of seizures while walking with a child. From the new stroller, I want it to stop as soon as possible if I lose consciousness while walking on the hill.
- As a user I want the stroller to be stylish and innovative and look good with my Tesla in the garage
- As a user I want to charge my phone and JBL from my stroller, that I can always be online.
- As a user, I want to have a mechanical handbrake to be independent from electricity

2.3 Existing solutions

1. Concord Neo. Concord – German carriage manufacturing company founded in 1978. In 2008 presented their flagship stroller first world known stroller with independent suspension. After its creation, many versions and improvements have arrived as the years have progressed, to now become one of the best strollers with independent suspension on the market.

2. Smartbe Intelligent Stroller - is a revolutionary concept that is self-propelled or assist-propelled. The stroller stays in front of the user seamlessly synchronized with their movement with neither assistance nor physical contact. In assist mode it easily reduces human effort for better control.

3. Skoda vRS Mega Man-Pram – baby stroller made by Skoda company, which is characterized as big-wheeled-car for babies.

2.4 BMC

The Business Model Canvas was proposed by Alexander Osterwalder based on his earlier book: Business Model Ontology. It outlines nine segments which form the building blocks for the business model in a nice one-page canvas. That's the most common instrument of presenting business strategy.[1]

Each block presents a certain business model element explained below.

FIGURE 2.3: BMC analysis

- 1. Customer segment
  For whom I am creating value and which segment is most important?
- 2. Value proposition
  How will I turn an unaware visitor into an interested customer? What can I offer a customer that he really needs? A clear and compelling one-liner message I want to send across.
- 3. Channels
  How will I reach my target consumers? Direct marketing, social media, ads, partnerships — these are the effective ways to reach them.
- 4. Customer relationships
  This block is about communication with the end-user. How am I going to review if everything is ok while using or choosing the product?
- 5. Revenue streams
  What money sources will grow money? How will I generate income? A pricing model of my product.
- 6. Key Resources
  Any resources that are going to be needed while production, advertising and selling the product and also documenting production.

- 7. Key Activities
  All the activities my value proposition requires. All the processes.
- 8. Key partners
  These are partners without whom the business itself cannot exist. The ones giving key resources.
- 9. Cost structure
  What are the fixed and variable costs to launch my product?

2.5 SWOT-analysis

SWOT analysis or SWOT matrix is strategic planning instrument used to help identify strengths, weaknesses, opportunities, and threats related to business competition.

FIGURE 2.4: SWOT analysis

3 Engineering

As there is the need to add comfort, off-road capabilities and maximum quality and durability to the product, especially on bad roads, I decided to create a spacious aluminum frame. The cradle and controls will be attached to the top and four wheels on independent suspension, two of which are motor wheels on the bottom side.

Based on the experience of SUVs, ATVs, UTVs, and off-road trucks, it was decided to use a two-lever independent suspension with shock absorber struts.

3.1 Independent suspension

The independent two-lever suspension is two V-shaped levers located one above another. The tops of the levers are hinged to the ends of the hub and the forked ends are attached to the frame.

FIGURE 3.1: Independent suspension (www.drive2.ru)

In my prototype the spring is used for the tone of the carriage and the shock-absorber is used for attenuation of oscillations. The best solution is to combine the spring and the shock absorber into one rack, it will give compactness and maintainability. The biggest advantage of this type of suspension is the large damping capacity required for comfortable crossing of high curbs, road pits and uneven seams, as well as the fact that the suspension does not change the inclination of the wheels. As it demonstrated on the image below. The upper and lower levers are always parallel to each other. That is, even with intense oscillation of the suspension, the wheels will always be perpendicular to the road, which adds safety and comfort.

FIGURE 3.2: Paralleled wheels (www.dirtwheelsmag.com)

In the automotive industry there is only one significant disadvantage of the two-lever suspension - such a system takes up a lot of hood space, which complicates the placement of the engine, but while designing a stroller it is not a problem, because the lower part of the frame is open and the cradle and all other units are high enough. So there is enough space for the suspension. In the central part of the frame, to which the levers are attached, battery is located to move the center of mass as low as possible.

Currently there is no stroller model on the market with an independent two-lever suspension on all four wheels. In most upgraded strollers the suspension is represented by interlocking wheels on the beam, which are shock-absorbed by weak plastic springs. This dependent suspension has insufficient comfort properties, because if the left wheel falls into the pit, the angle of the right wheel will be directed to the left, and will pull the entire frame of the stroller to the left side. Because of this, the cart will shake violently on pits and uneven surfaces.

4 Electronics

4.1 Battery

There are several types of chemical batteries on the market nowadays. Prior to the invention of lithium-ion batteries(in 1980s), the undisputed market leaders were lead-acid batteries. These are really good for electrical transport where the weight is not a key characteristics. Lithium-ion (Li-ion) is currently the most popular due to its low weight, low cost and durability. Another great type of batteries is LiFePO4. They have better temperature range, more charge-discharge cycles and bigger lifetime, but there are some cons comparing to Li-ions, as bigger weight and higher price.Also, Li-ion batteries have the highest efficiency coefficient - 95percent ,what is 15percent higher than lead-acid batteries level. That's one more thing why I would use Li-ion.A lot of different manufacturers are presented on the market with their products, but as experience shows Samsung company is the race dealer. The declared capacity of their batteries corresponds to the actual.

Every Li-ion battery has its Battery Management System(BMS), which does current protection (protects from short circuit and higher current level) , voltage protection (protects from overcharging and overdischarging), temperature protection and balancing (evenly distributes the charge between all cells of the battery, due to which the battery life is maximized.)

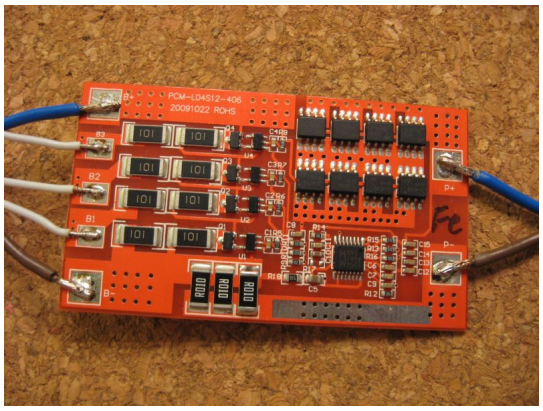


FIGURE 4.1: Battery Management System (www.electricaltechnology.org)

Structurally on the board are placed:

- protective chip
- analog wiring (for detecting current / battery balancing)
- power transistors (to disconnect the load)

Using Battery Management System capabilities we can easily track battery charge level (SOC- state of charge) and theoretically lifetime cycles. The most accurate results for the SOC estimation can be obtained by OCV (Open Circuit Voltage) measurement after the load is removed.[8]

Lithium batteries are charged in 2 stages: CC (constant current) and CV (constant voltage). The charger gradually raises the voltage so that the charged cell takes back current (the usual recommended value is 1 battery capacity). When the voltage reaches 4 V, charging proceeds to the second stage and maintains a voltage of 4.2 V on the battery.

4.2 Motor wheel

An electric vehicle is propelled by electric motors of either AC or DC, which is internal combustion engine alternative due to pollution concern, cost, and availability of the oil. AC and DC motors have the same function - converting electrical energy into mechanical energy, while they are powered, constructed and controlled differently. [10] The biggest difference is that AC motors are powered by alternating current when DC - from direct current such us batteries, other DC supplies or an AC-to-DC power converter. The speed of a D.C. motor is controlled by varying the armature winding's current while the speed of an A.C. motor is controlled by varying the frequency, which is commonly done with an adjustable frequency drive control. [4]

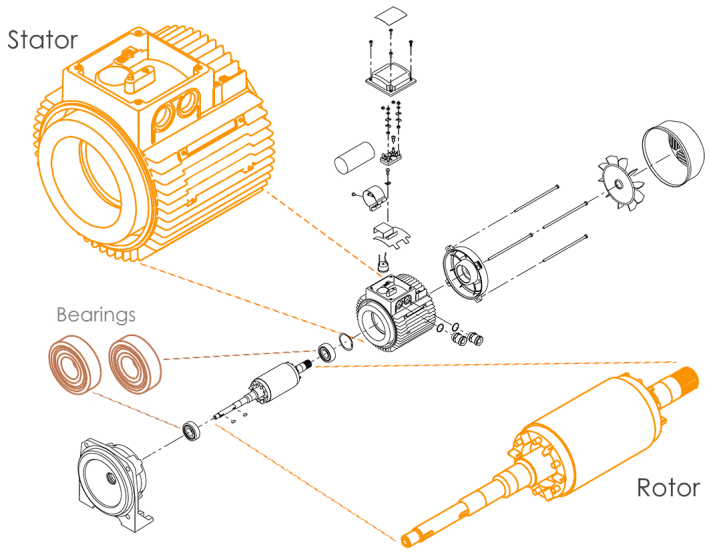


FIGURE 4.2: Electic gear motor construction

DC motors are mainly used in production since batteries are used as the main power source. BLDC motors are often used in techniques due to high efficiency, high power density, large starting torque, noiseless operation, low weight and smaller in size. Modern vehicles are powered by hub type BLDC motors, motors in-build in the wheel, to avoid complex powertrain mechanism.

Unlike conventional brushed type DC motor, wherein the brushes make the mechanical contact with commutator on the rotor so as to form an electric path between a DC electric source and rotor armature windings, BLDC motor employs electrical commutation with permanent magnet rotor and a stator with a sequence of coils. In

this motor, permanent magnet (or field poles) rotates and current carrying conductors are fixed.

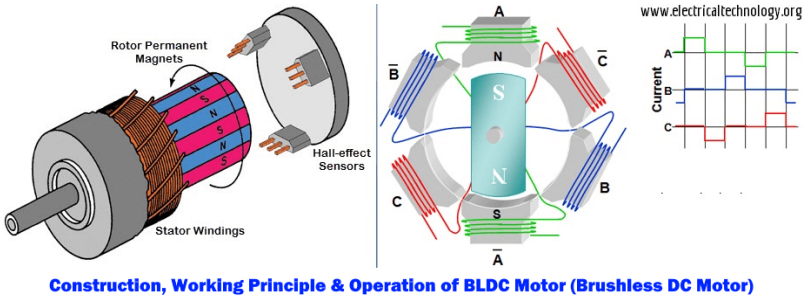


FIGURE 4.3: BLDC motor construction (www.electricaltechnology.org)

To rotate the motor continuously the electronic controller scheme turn on appropriate motor winding by turning transistor or other switches. The figure below shows a simple scheme of a BLDC moto: MOSFET bridge (inverter bridge), an electronic controller, a Hall effect sensor, and a BLDC motor. In addition to switching to the rated engine speed, an additional electronic circuit can change the engine speed. Typically, these speed control units are PID controllers.

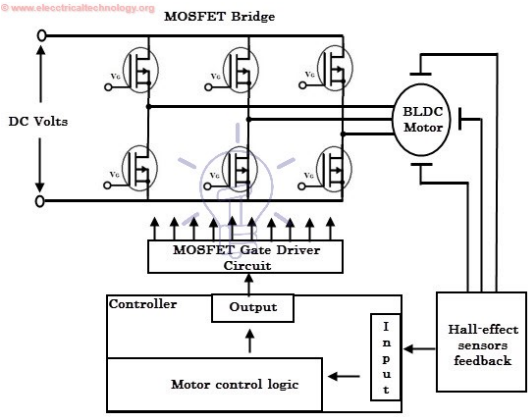


FIGURE 4.4: BLDC working scheme (www.electricaltechnology.org)

In my project for MVP I use regular 3phase *Anaheim* BLDC motor BLY171-174S with a motor driver for it.

Wire Color	Description
Red	Hall Supply
Blue	Hall A
Green	Hall B
White	Hall C
Black	Hall Ground
Yellow	Phase A
Red	Phase B
Black	Phase C

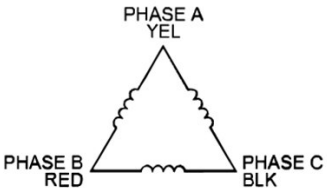


FIGURE 4.5: *Anaheim* BLY motor logic (www.anaheimautomation.com)

4.3 PID Controller

The main goal while creating smart brakes system and electronic handbrakes is to make a system which will work similarly to ABS Anti-lock braking system. It prevents the wheels from locking up and helps them maintain grip with the road below. The main purpose of the ABS is to ensure optimal braking efficiency while maintaining the stability and control ability of the car. ABS generally offers improved vehicle control and decreases stopping distances on dry and some slippery surfaces, when on snowy surfaces improve control level and increase stopping distance. Why is this important? Without ABS a car on the road with it's big weight and high speed can cause skidding while braking. In terms of baby trolley locking up the wheels can cause flipping a stroller due to high center-of-mass location.

In such difficult practical problems as designing an ABS great result shows using fuzzy logic controls.[9] A fuzzy control system, which is the system that fuzzy controls use, analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively).[11]

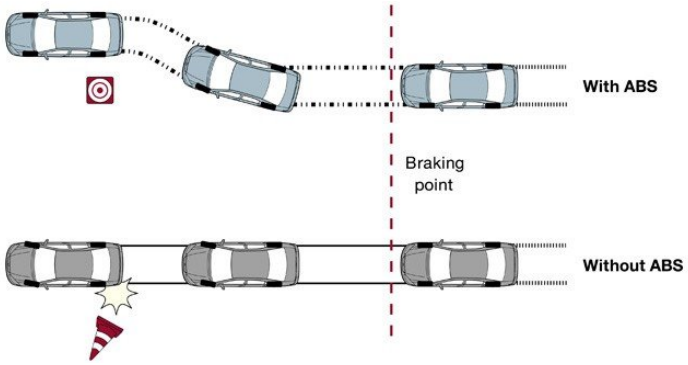


FIGURE 4.6: ABS working principle(www.toyota.lk)

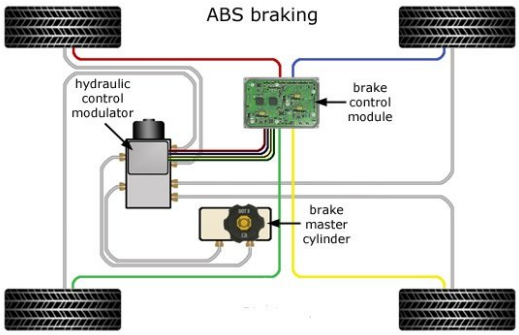


FIGURE 4.7: ABS working scheme (www.agcoauto.com)

In some cases for an car ABS fuzzy or regular PID controllers are used.[3] What is PID (proportional–integral–derivative) controller by itself? It is a loop mechanism which is used in automatic control systems to generate a control signal in order to obtain the necessary accuracy and quality of the transition process. To simplify the explanation I would say that if you have something like a car you might want to have a cruise control in it which maintains a constant speed of the car, automatically adding gas when the speed decreases and decreasing when it increases, for

example, on the slopes, without the participation of the driver. This is what PID controller does it takes some variable for example speed and compares it with some ideal constant in 3 phases:

- If IT(speed) is higher/lower than a Constant (Proportional phase),
- and the deviation between the speed and a ideal constant becomes bigger (Integral phase)
- and the speed of the deviation increase increases (Derivative phase)
- Then command - decrease/increase the speed.

One more version to explain PID controller working process is to make an analogue with time where Proportional component is Present (if the speed is bigger now?), Integral component is Past (if the speed is bigger for some time?), Derivative is Future(what the speed are going to be next moment?) and summarizing all of the components answers the best decision can be made.

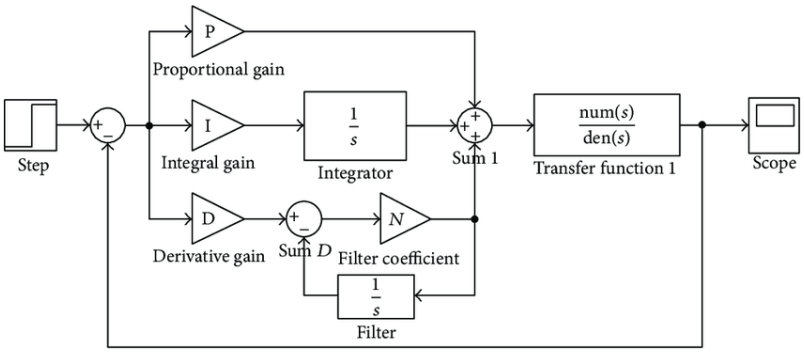


FIGURE 4.8: PID controller working scheme (www.researchgate.net)

When you try to press the brake-pedal while ABS is working you would feel the vibrating pulsation this mean that controller is giving a brake signal using PWM.[12]

Unfortunately, it is hardly to use PID in emergency braking system, due to small speed differences. PID controllers are used in wider speed ranges (automotive and rocketry), but with really small values it will take too long to respond. The alternative way is to use PI controller, without a derivative component. Or create totally independent software algorithm for smart braking system. MVP testing is needed to decide which variant is better, second or third.

4.4 PWM

One very simple and easy way to control the speed of DC motors is to use PWM. Pulse-width modulation - is a method that helps reduce electric power by chopping signals into discrete parts. It gives the analog results with digital means. Also in small motors the power loss in the switching transistor is small because the transistor can be just ON or OFF. It results in more stable speed.

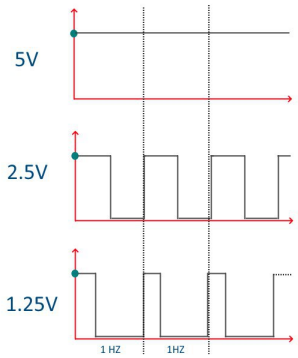
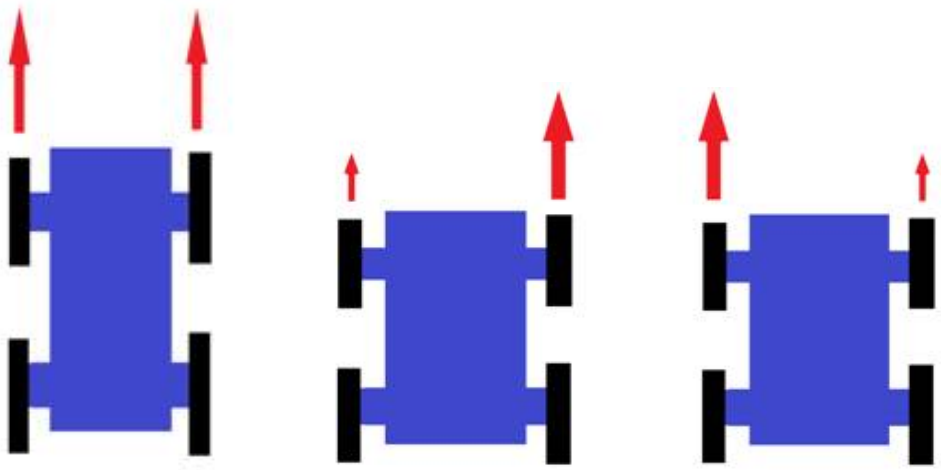


FIGURE 4.9: PWM signal

4.5 Speed control

For MVP I use regular joystick with the analog signal in two axis which gives two analog signals (0-1023, 0-1023). Since there is no full backward stroller moving provided (except braking when motors do pulsating backward move using PWM). Vertical axe gives easier or harder forward move and horizontal axe gives the small or big difference in wheel speeds in accordance to joystick output. This how we can make easier turns in addition to forward move.



(A) Forward move (B) Turn left (C) Turn right

FIGURE 4.10: Different stroller moves

4.6 Distance sensor

Distance sensor functions by outputting a signal (depending on technology: ultrasonic waves, IR, LED, etc.) and measuring the change when the signal returns. There are two ways which change to measure:

- Time taken to send and receive signal
- The intensity of received signal

By simple formulas both of ways can be used to calculate the distance between a sensor and a target.

Ultrasonic sensor

The first technology commonly used in markets is using ultrasonic waves. Also known as the Sonar sensor, it detects the distance to objects by emitting high-frequency ultrasonic waves (from the transmitter(trig pin)) and calculating time till the wave is received back (to the echo pin), the time is used to calculate the distance.

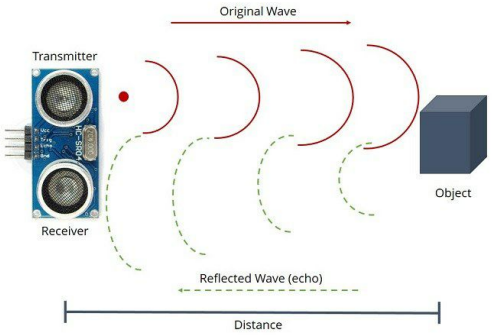


FIGURE 4.11: Infrared sensor working principle

IR distance sensor

The second on the list is infrared distance sensor which works through the principle of triangulation. IR LED emitter lens emits a light beam, it reflects from an object and a position-sensible photodetector (PSD) receive the beam. Then the angle between emitted and reflected light beam is measured and distance is calculated using a formula

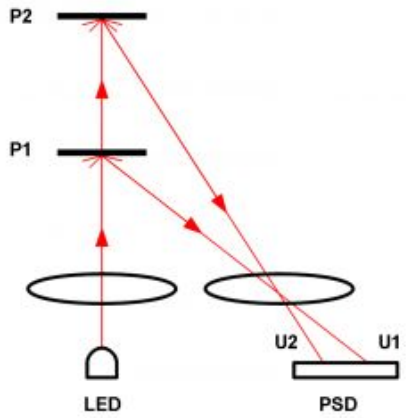


FIGURE 4.12: Infrared sensor working principle

Laser distance sensor. LiDAR Sensor

LiDAR is short for Light Detection And Ranging. It measures the distance through light waves from a laser instead of radio or sound waves. The transmitter emits laser light, target object reflects the light back and the distance is easily calculated using the constant speed of light in air and time between sending and receiving the signal.

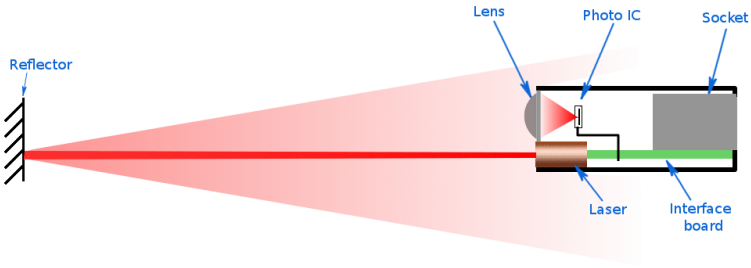


FIGURE 4.13: Laser sensor working principle

LED Time-Of-Flight Distance sensor. This sensor is the smallest flight ranging and gesture detection sensor.This types of sensors are very accurate and really good in 3D imaging. Works similarly to Lidar sensors.
Summarizing all of the info I made comparison table. And decided that I will include 3/4 distance sensors types in my MVP to test what type would be the best on practice. The only one I definitely will not use is LiDAR sensor due to high price.

	Sutability for long range sensing	Cost	High reading frequency	Sensitive to external conditions
Ultrasonic sensor	NO	LOW	NO	YES
IR sensor	NO	LOW	NO	NO
Lidar sensor	YES	HIGH	YES	NO
Time-Of-Flight	YES	MODERATE	YES	NO

FIGURE 4.14: Distance sensor comparison table

4.7 Tactile sensor

To check whether a person holding a stroller or not multiple sensors and checking algorithms were analyzed. A tactile sensor is a device that measures the received information in response to the physical interaction with the environment. [2]

The first one was a heart rate sensor, which basically is a powerful LED, a special brightness sensor, an active filter and a useful signal amplifier on the operational amplifier. The working principle of the sensor based on the change of light reflection by the skin and measuring how it scatters off blood vessels.

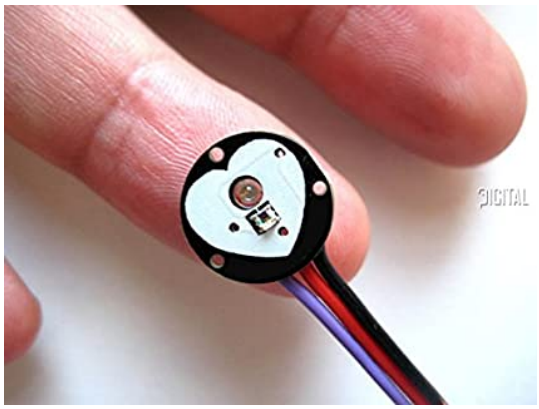


FIGURE 4.15: Heart-rate sensor (amazon.com)

- Pros - it is cheap, easy to use
- Cons - it is really small so hands should be straight in one position, it is an optical sensor so it is not desirable to press it firmly against the skin and you need to avoid exposure to external light sources.

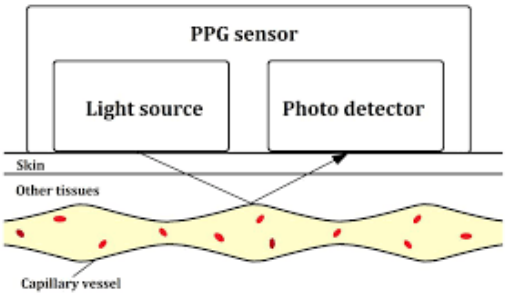


FIGURE 4.16: Heart-rate sensor working principle (www.researchgate.net)

Second type is FSR sensors. FSRs are sensors that allow you to detect physical pressure, squeezing and weight. The round part is the sensitive bit. Basically these are resistors that change their resistance value (in Ohms) depending on the force on the surface. When there is no pressure, the sensor looks like an infinite resistor, as the pressure increases, the resistance goes down. What is especially important that the low force measurements it quickly goes from infinite to 100(KOhms).

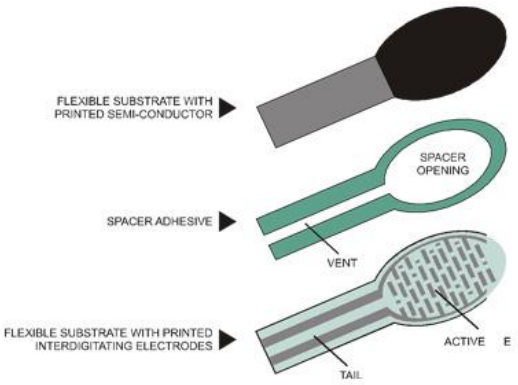


FIGURE 4.17: Force sensible sensor working principle (www.mouser.com)

Here is a table of dependencies between force and resistance value, where R is pulldown resistor. They are easy to use, low cost but rarely accurate. Thankfully for this project I do not need weight accuracy so this sensor fits perfectly on the stroller's handle.

Force (lb)	Force (N)	FSR Resistance	(FSR + R) ohm	Current thru FSR+R	Voltage across R
None	**None**	Infinite	Infinite!	0 mA	0V
0.04 lb	**0.2 N**	30 Kohm	40 Kohm	0.13 mA	1.3 V
0.22 lb	**1 N**	6 Kohm	16 Kohm	0.31 mA	3.1 V
2.2 lb	**10 N**	1 Kohm	11 Kohm	0.45 mA	4.5 V
22 lb	**100 N**	250 ohm	10.25 Kohm	0.49 mA	4.9 V

FIGURE 4.18: Force sensible sensor table (www.mouser.com)

4.8 PID Controller

The main goal while creating smart brakes system and electronic handbrakes is to make a system which will work similarly to ABS Anti-lock braking system. It prevents the wheels from locking up and helps them maintain grip with the road below. The main purpose of the ABS is to ensure optimal braking efficiency while maintaining the stability and control ability of the car. ABS generally offers improved vehicle control and decreases stopping distances on dry and some slippery surfaces, when on snowy surfaces improve control level and increase stopping distance. Why is this important? Without ABS a car on the road with it's big weight and high speed can cause skidding while braking. In terms of baby trolley locking up the wheels can cause flipping a stroller due to high center-of-mass location.

In such difficult practical problems as designing an ABS great result shows using fuzzy logic controls. A fuzzy control system, which is the system that fuzzy controls use, analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively).[11]

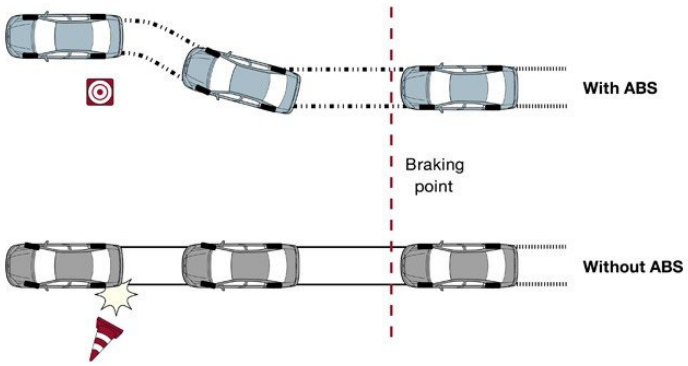


FIGURE 4.19: ABS working principle (www.toyota.lk)

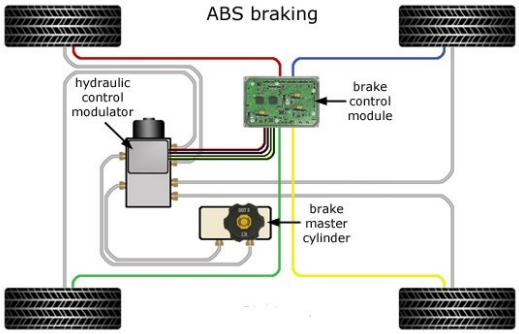


FIGURE 4.20: ABS working scheme (www.agcoauto.com)

In some cases for an car ABS fuzzy PID controllers are used.[3] What is PID (proportional–integral–derivative) controller by itself? It is a loop mechanism which is used in automatic control systems to generate a control signal in order to obtain the necessary accuracy and quality of the transition process. To simplify the explanation I would say that if you have something like a car you might want to have a cruise control in it which maintains a constant speed of the car, automatically adding gas when the speed decreases and decreasing when it increases, for example, on the slopes, without the participation of the driver. This is what PID controller does it takes some variable for example speed and compares it with some ideal constant in 3 phases:

- If IT(speed) is higher/lower than a Constant (Proportional phase),
- and the deviation between the speed and a ideal constant becomes bigger (Integral phase)
- and the speed of the deviation increase increases (Derivaive phase)
- Then command - decrease/increase the speed.

One more version to explain PID controller working process is

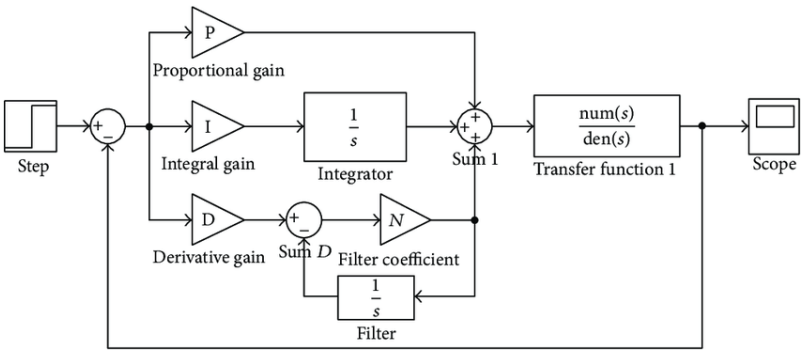


FIGURE 4.21: PID controller working scheme (www.researchgate.net)

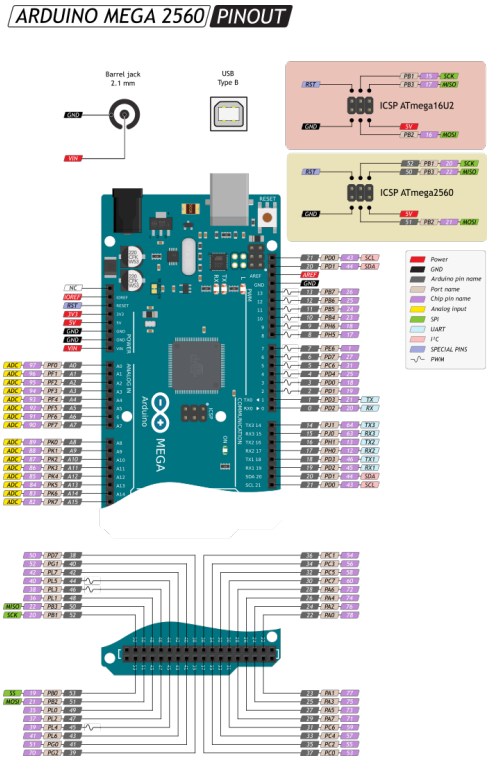
When you try to press the brake-pedal while ABS is working you would feel the vibrating pulsation this mean that controller is giving a brake signal using PWM.

4.9 Microcontroller

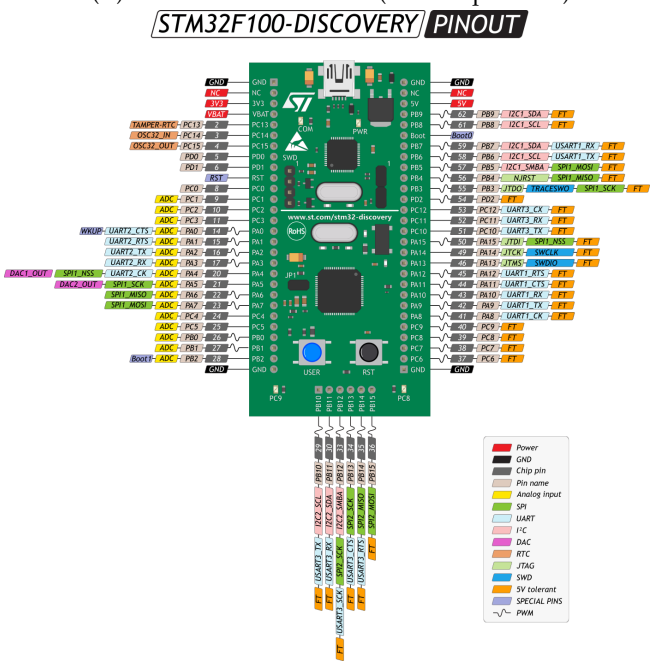
There is huge amount of absolutely different microcontrollers. Single-chip microcontrollers (MK) are intended for use in industrial and household automation systems. They are large integrated circuits that include all the devices necessary for implementing a digital control system with a minimum configuration: processor, memory of commands, memory of data, clock generator, programmable devices for communication with the external environment (interrupt controller, timer counters, various input / output ports), sometimes analog-to-digital and digital-to-analog converters, etc. In order not to describe all the differences between them here is a list of characteristics according to which I choose the one.

- easy to program
- low price
- small in sizes
- PWM pins
- sufficient speed

Since big amount of modern microcontrollers can do that I choose two that I used to work with. An Arduino Mega for MVP and the STM32 Discovery for production version of a stroller. Both of the microcontrollers presented have 16 PWM pins, 2 I2C interface pins



(A) Arduino MEGA Pinout(wiki.amperka.ru)



(B) STM32 Pinout(wiki.amperka.ru)

4.10 Scheme

Summarizing all of the component analysis here is an electronic part scheme.

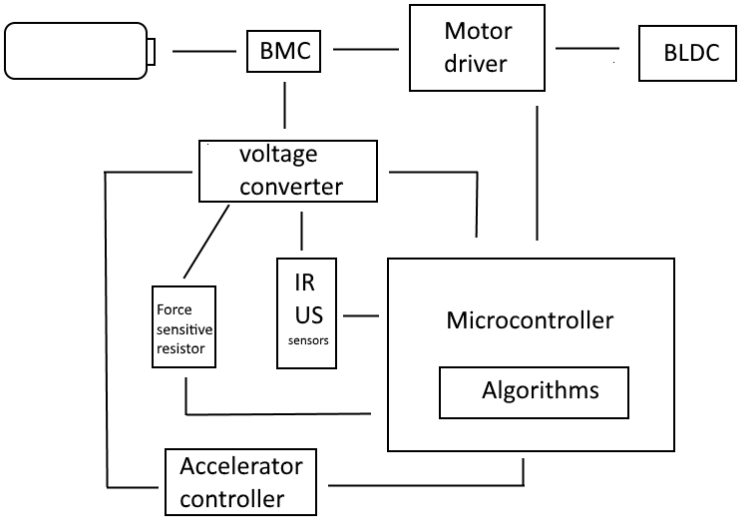


FIGURE 4.23: Stroller working scheme

5 Code

5.1 Emergency Brakes Algorithm

The emergency brake algorithm uses the information from tactile sensor (force-sensible sensor), ultrasonic sensor, infrared sensor, hall sensors from which we know the answers for a number of questions.

- If the hands are on the handle or not?
- If the stroller is moving?
- How fast the stroller moves?
- How fast the stroller is moving?
- If there is some barrier on the way?
- How far the barrier is?

So the logic is - IF (hands are not on the handle AND acceleration is not equal to zero (stroller is moving) for more then 2 seconds) OR the distance to the barrier is less then 30cm THEN motor should stop.

Using PWM method controller send to the motor driver a command to stop the motor (pulsating signals(-1) to spin backward) using a dependency function between the speed and the acceleration to choose the right frequency for PWM signal.

5.2 Swing Algorithm

According to my observations and tests with different people, the average value of the distance traveled by the stroller when rocking a child is 97cm. By simple calculations we get the circle length from a wheel radius. Now dividing mean value from my tests by the circle we can get number of turns the wheel need to do.

After that controller send to the motor driver a command to do straight amount of turns forward (drive forward), then slowly stop, then do straight amount of turns backward (drive backward) then slowly stop and so on.

Speed is also controlled (stabilized) by PWM on the stated frequency.

The stopping function is realized in the same way as in emergency braking.

6 Conclusion

The topic for this work was chosen by me not by chance. A few years ago, my youngest brother was born, four more siblings before him, and recently my own son appeared in this world, and when I just started to walk outside with my brother's stroller, I noticed a lot of problems with the stroller market. In a world where the best is done for children, the highest quality, where the compositions of dry mixes for feeding is better than the menu in the most expensive restaurant, where safety regulations for child car seats are stricter than the rules of making spacecraft, no one pays attention to the stroller market. And I'm sure that if this problem has affected me, it has affected thousands of young parents who cannot buy a stroller that meets the pace of modern innovation just because it not exist. Why, when we can ride hoverboards, we can't easily control a stroller with the most expensive we have? Why, launching rockets to another planet, people still didn't made a comfortable suspension on a baby, damn, stroller? I am sure that many people ask themselves these questions, but few have the ability and opportunity to change something. So I decided to try, to make a smart and modern device to make the time of walking with your child more enjoyable, comfortable and safer.

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