Concept Generation & Selection

Team # 17

Michael Bunne, John Jagusztyn, and Jonathan Lenoff
Department of Mechanical Engineering, Florida State University, Tallahassee, FL

Project Sponsor:

CISCOR
CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS

Project Advisors:
Dr. Emmanuel G. Collins, Ph.D
Department of Mechanical Engineering
Dr. Oscar Chuy, Ph.D
Department of Mechanical Engineering

Introduction

Problem Statement

The current generation of assistive walking devices is limited in their traversable terrain and functionality.

- **Indoor operation only**
- **Only perform basic functions**
- **Scooters / electric wheelchairs unnecessary or expensive**

Proposed Solution

Develop a walking assistive device designed to actively assist the user in both indoor and outdoor maneuverability.

- **Further empower the disabled and elderly community**
- **Offer wide-range of assistive functions**
- **Maintain ease of use and intuitiveness integral to current generation walkers**

Existing Devices

National Taiwan University: Advanced Control Lab “Assisted walker robot”

- **Designed to assist in post-surgery rehabilitation**
- **Provides stability, walking gait suggestions, fall prevention**
- **Indoor operation only**
- **Not for day-to-day use**
- **Not semi-omni-directional**

Existing Devices

Korean Center for Intelligent Robotics outdoor assistive walking system

- **Designed to offer walking assistance outdoors**
- **Provides stability and fall prevention**
- **Limited indoor and moderate outdoor operation**
- **Not semi-omni-directional**

Specifications

Frame

- Resemble current generation walker in aesthetics and standards
- 1 inch diameter aluminum piping
- Supports up to 300 pounds
- Adjustable heights between 32 and 39 inches
- Adjustable handle width between 11 and 24 inches

Propulsion

- Minimum 11 inch diameter wheels or tracks
  - Travel over all indoor surfaces, grass, gravel, sand…
  - Travel up or down slopes up to 10 °
- Move transversely 45° from the center axis
- Maximum operating speed of 5 mph

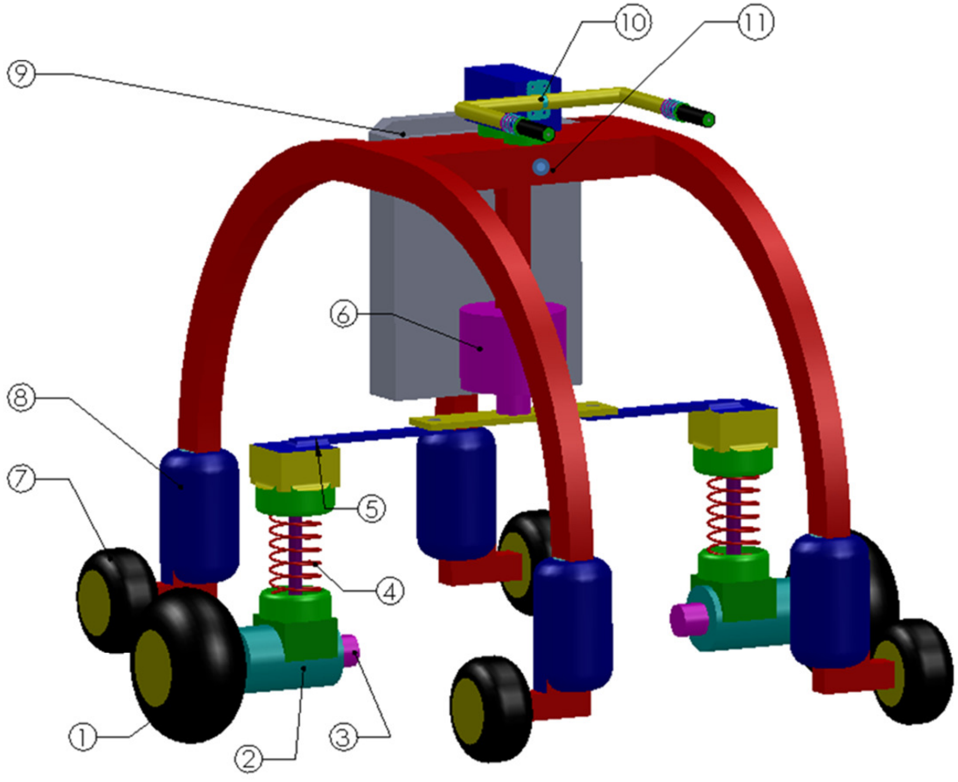
Control & Function

- Intuitive user input
  - Force-based drive control
- Fall Prevention
- Sit-Down/Stand-Up Assistance
- Object Detection/Avoidance
- Localization & Navigation

Criteria

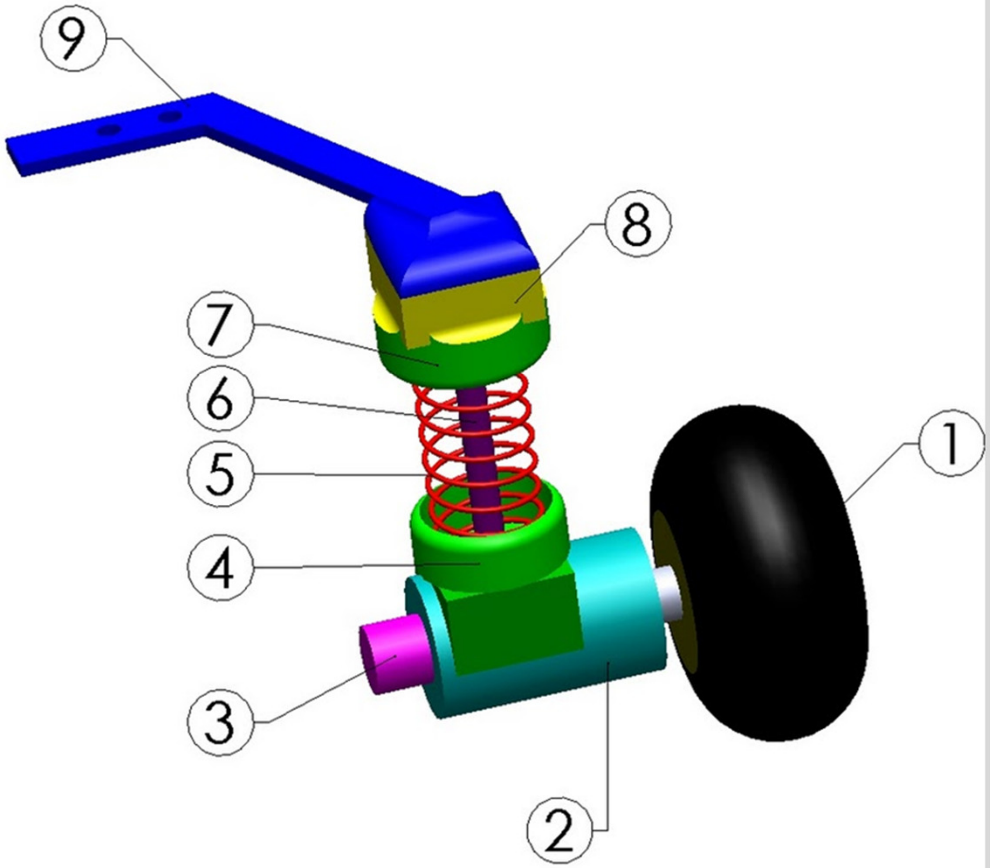
- Versatility
- Robustness
- User-friendliness
- Indoor operation
- Outdoor operation
- Cost
- Weight

Concept 1 Design



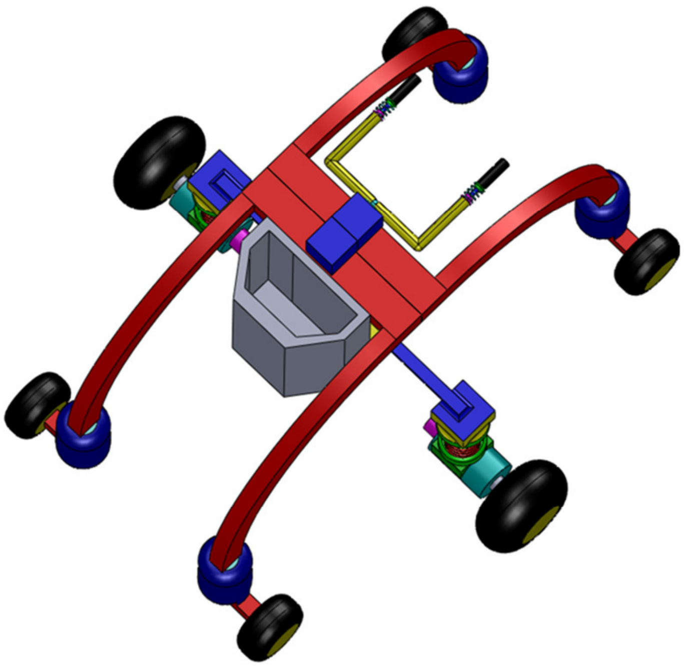
1) **Driving Wheel**
2) **Driving Motor**
3) **Motor Encoder**
4) **Spring & Damper**
5) **Ackerman Steering**
6) **Steering Motor**
7) **Caster Wheel**
8) **Caster Suspension & Swivel**
9) **Basket / Electronics**
10) **Force Plate**
11) **Camera**

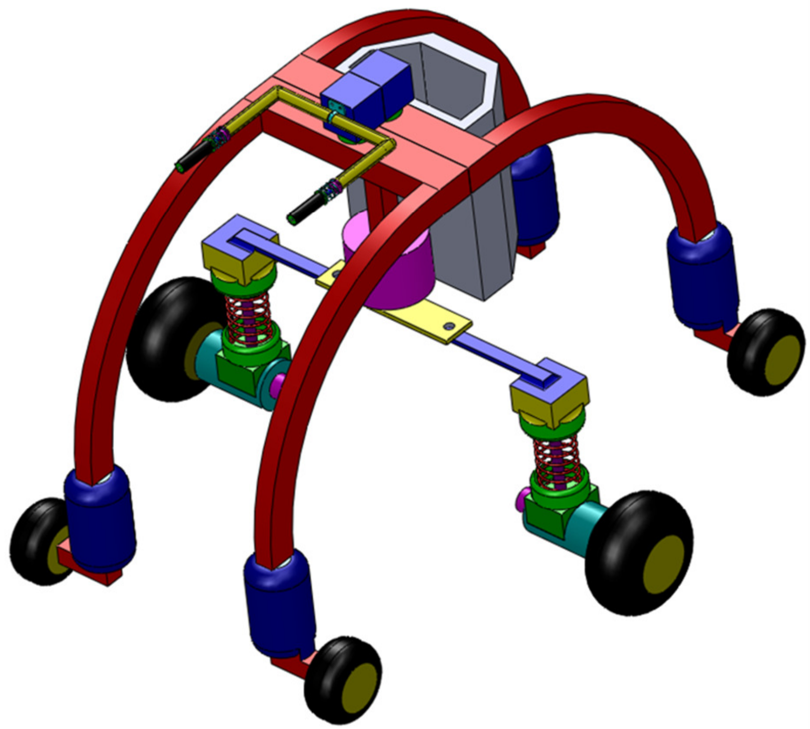
Concept 1 Design



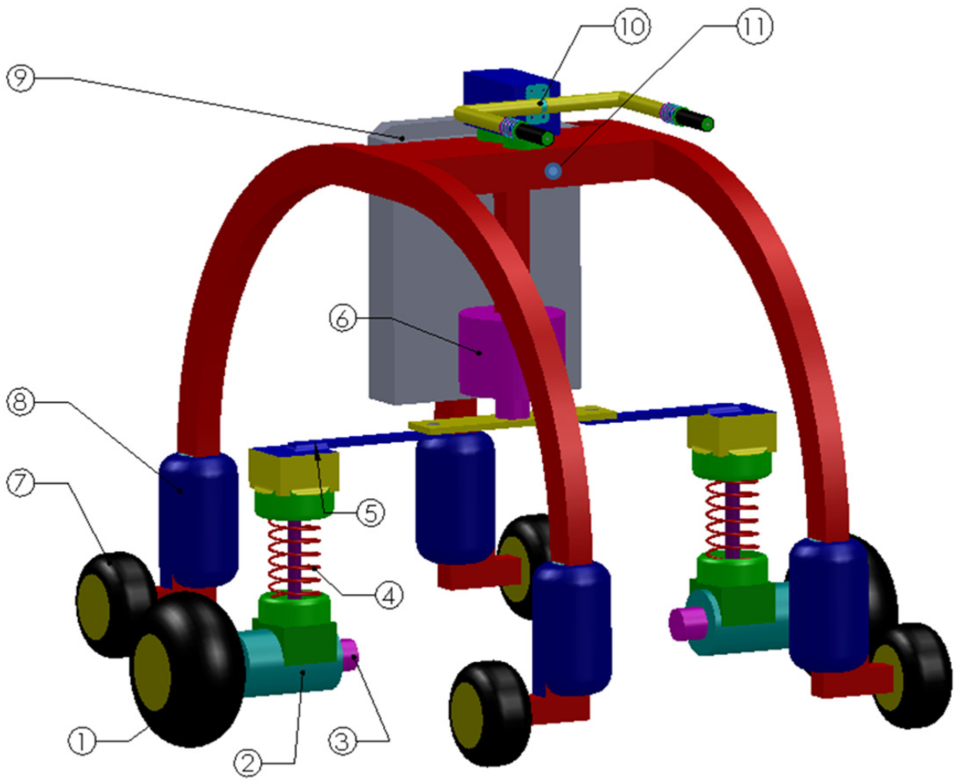
1) Driving Wheel
2) Driving Motor
3) Encoder
4) Elbow Couple
5) Adjustable Spring
6) Damper
7) Spring Housing
8) Elbow Couple
9) Ackerman Steering

Concept 1
Design





Concept 1 Pros/Cons



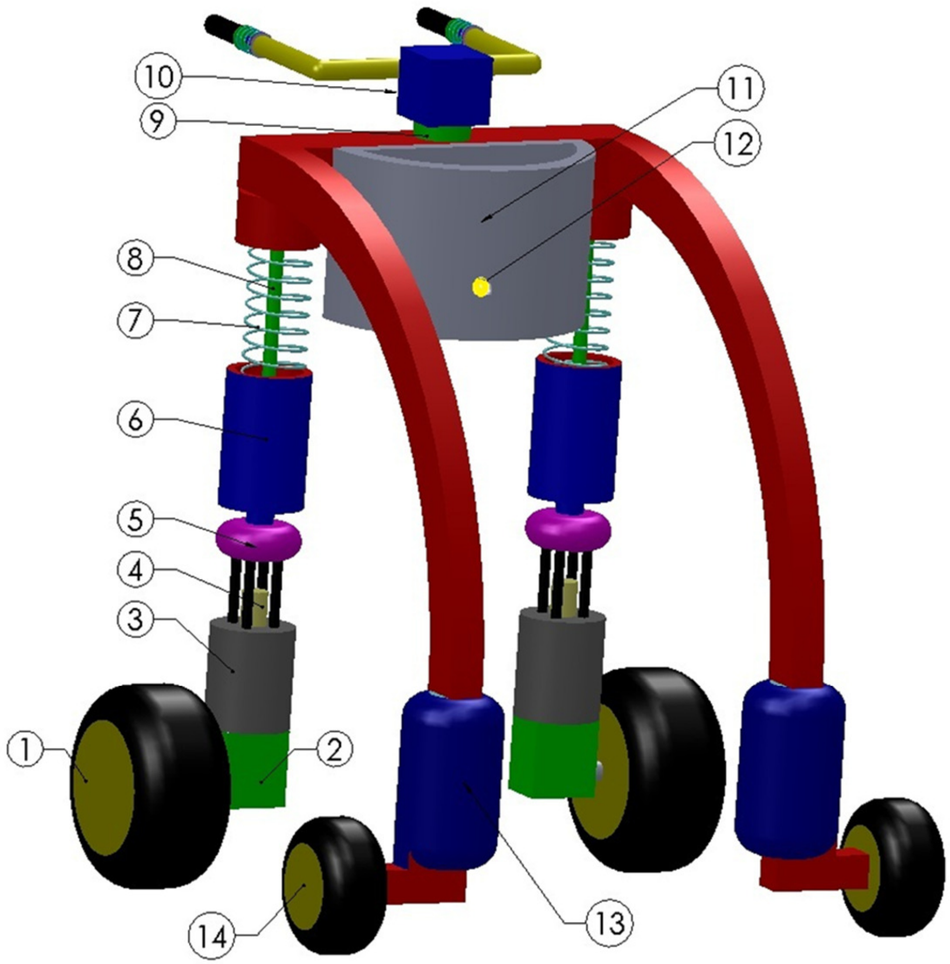
Pros:

1. **Sturdy, well balanced and robust**
2. **Ample electronics space**
3. **Common implementation of steering and driving motors**
4. **Good outdoor operation and traversibility**

Cons:

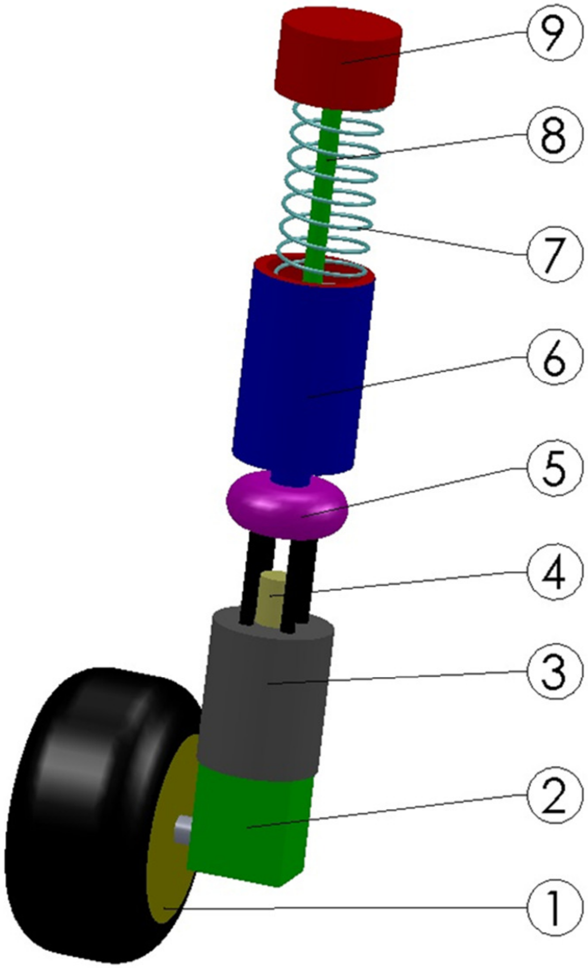
1. **Limited steering capabilities**
2. **Fragile Tires**
3. **Large/Heavy Structure**
4. **Foreign walker design**
5. **Expensive**

Concept 2 Design



1) Honeycomb Wheel
2) Elbow Gearbox
3) Driving Motor
4) Encoder
5) Rotary Connection
6) Steering Motor
7) Spring
8) Damper
9) Controls Base
10) Spring Driven Controls
11) Basket / Electronics
12) Camera
13) Swivel and Suspension
14) Caster Wheel

Concept 2 Design



1) Honeycomb Wheel

2) Elbow Gearbox

3) Driving Motor

4) Encoder

5) Rotary Connection

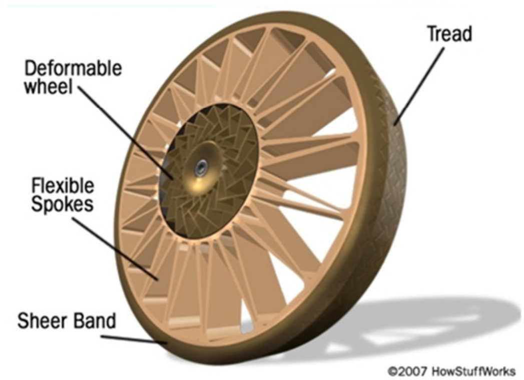
6) Steering Motor

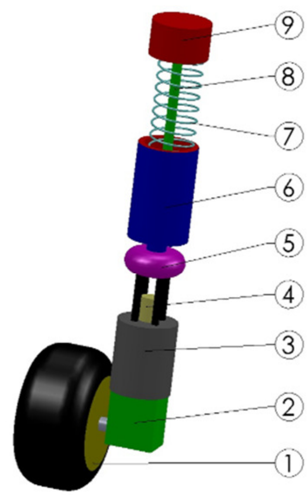
7) Spring

8) Damper

9) Spring Housing

Concept 2 Design





1) Honeycomb Wheel

2) Elbow Gearbox

3) Driving Motor

4) Encoder

5) Rotary Connection

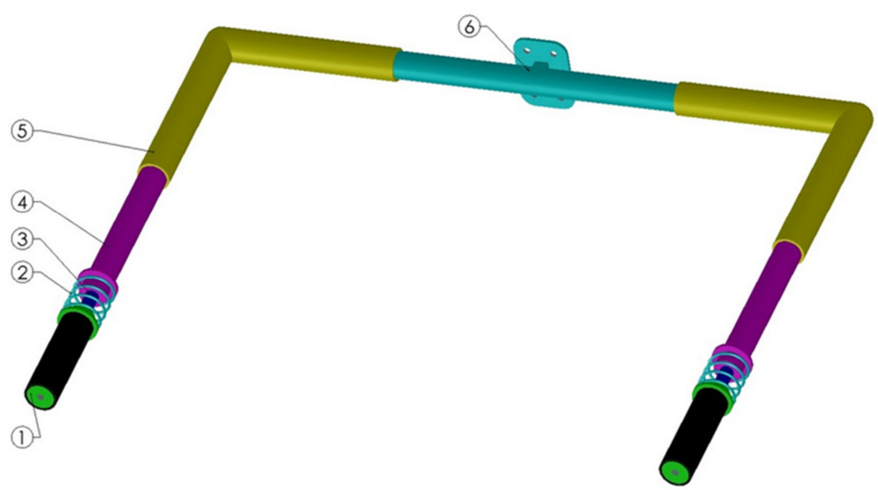
6) Steering Motor

7) Spring

8) Damper

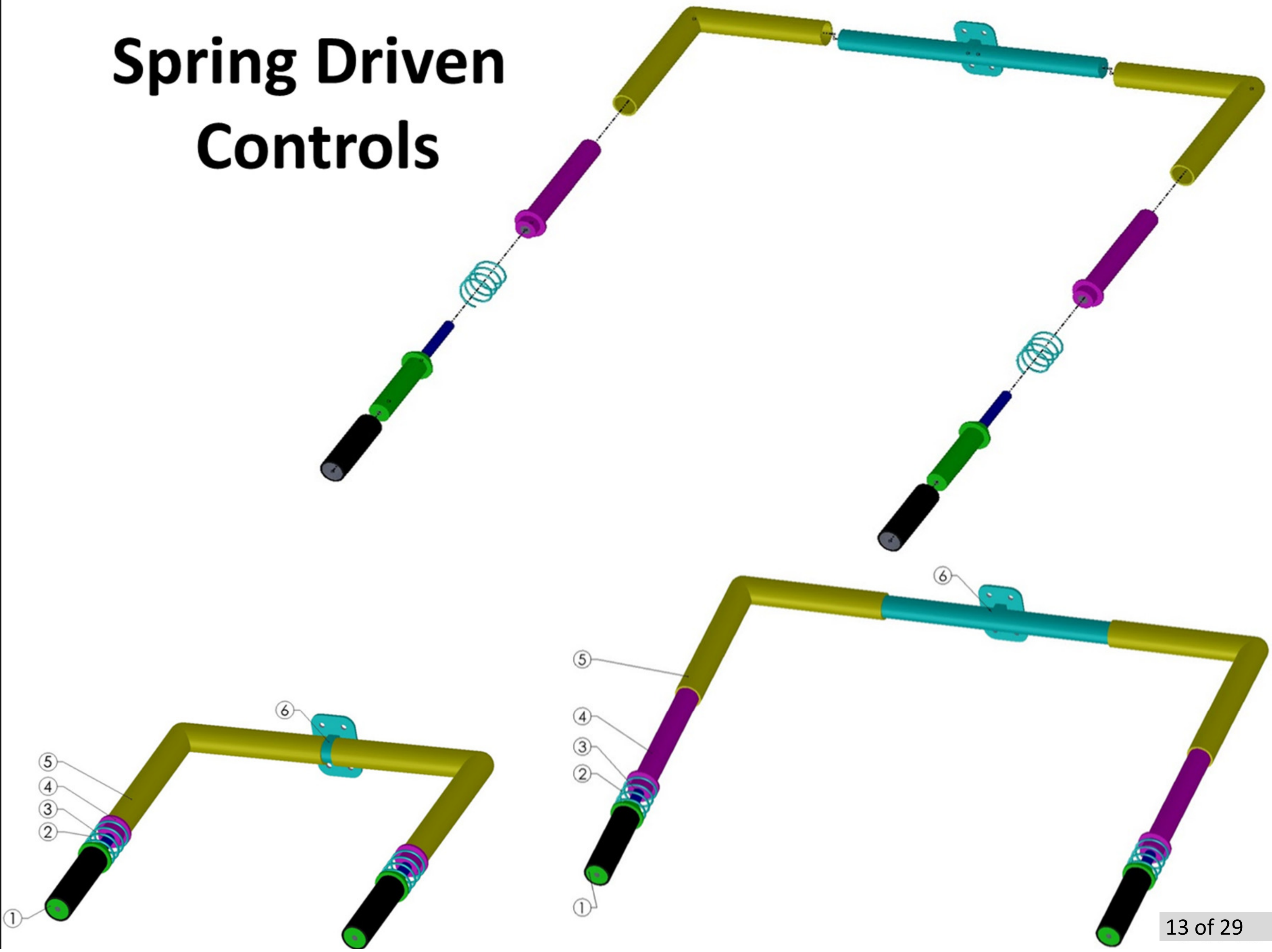
9) Spring Housing

Spring Driven Controls

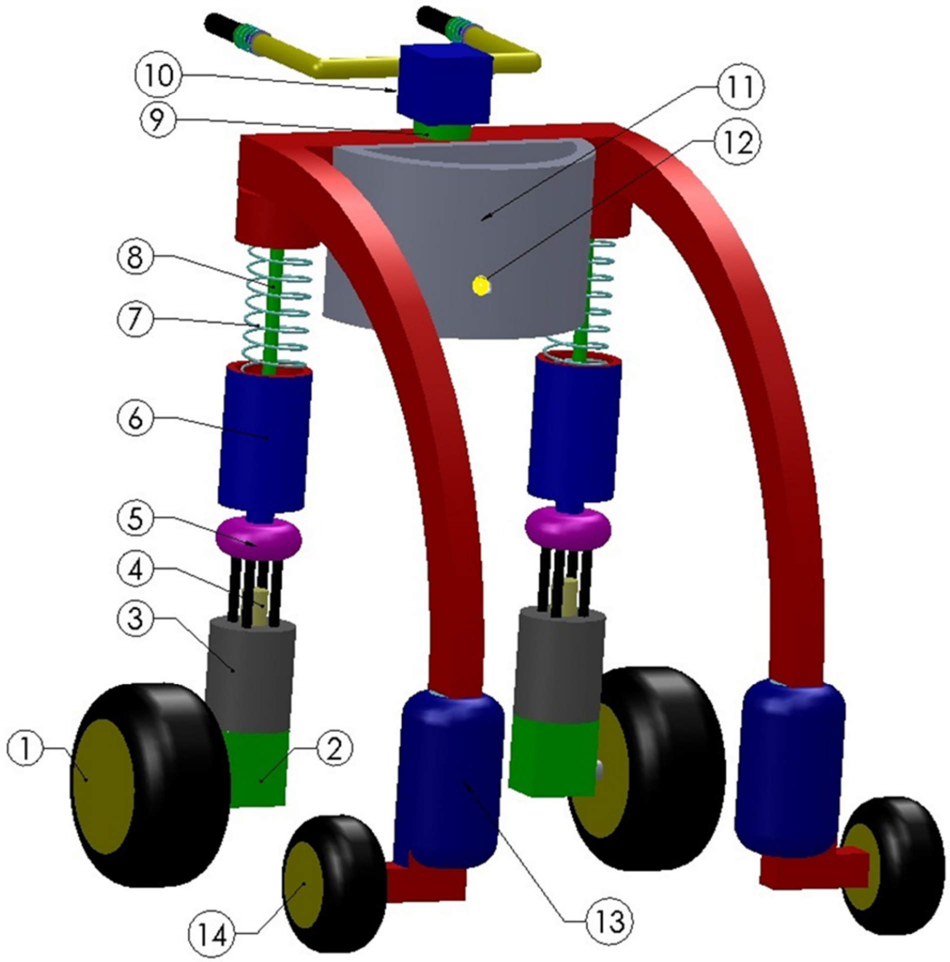


1) Grip
2) Damper
3) Spring
4) Depth Adjustment Shaft
5) Adjustment Shell
6) Mount / Width Adjustment Shaft

Spring Driven Controls



Concept 2 Pros/Cons



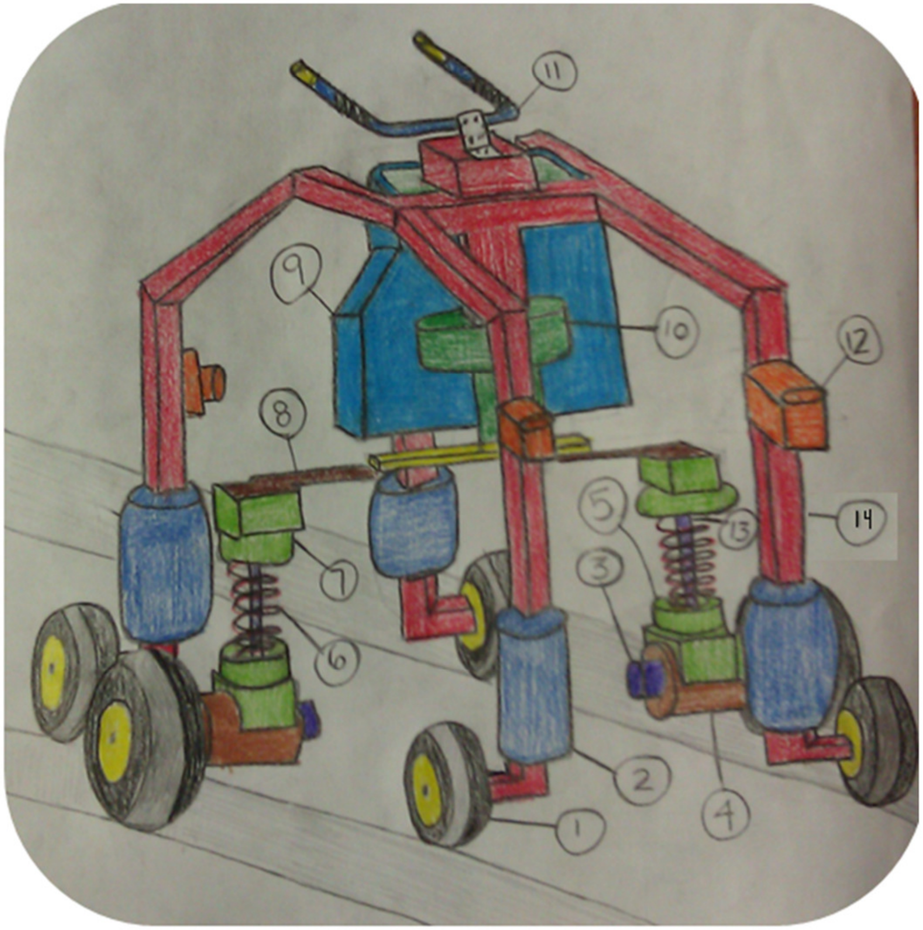
Pros:

1. Familiar walker design
2. True omni-directional movement
3. Cheap, sturdy controls
4. Puncture-less tires
5. Excellent versatility
6. Extremely user-friendly

Cons:

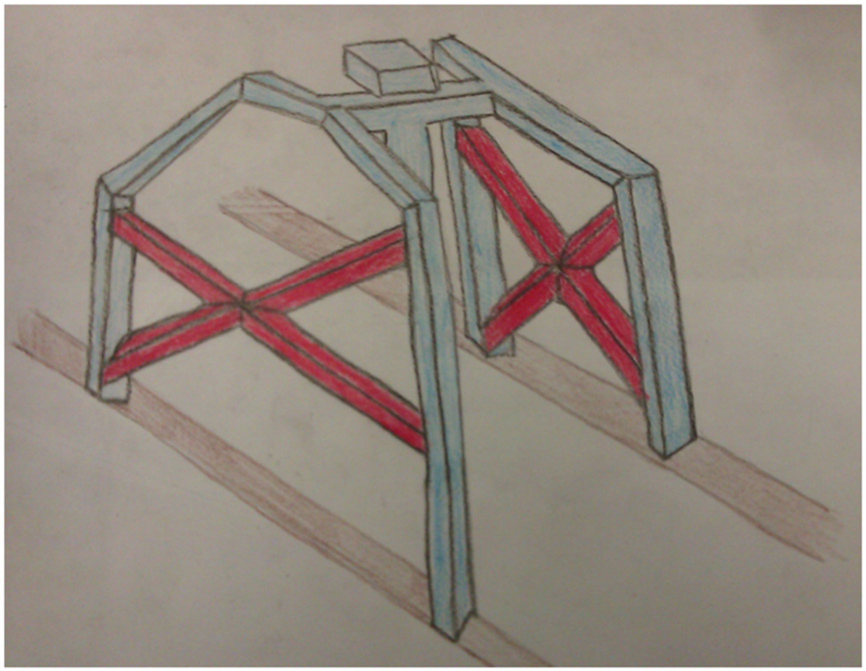
1. Single tire failure could render walker useless
2. Less backwards stability
3. Limited space for electronics
4. Limited payload capacity
5. Additional motor and electronics required
6. Expensive

Concept 3 Design



1) Caster Wheel
2) Caster Suspension / Shaft Swivel
3) Motor Encoder
4) Driving Motor
5) Spring Elbow Couple
6) Spring
7) Spring Housing
8) Ackerman Steering
9) Basket / Electronics
10) Steering Motor
11) Spring Driven Handle
12) Laser Sensor
13) Spring Dampers
14) Frame

Concept 3 Design



1) Caster Wheel
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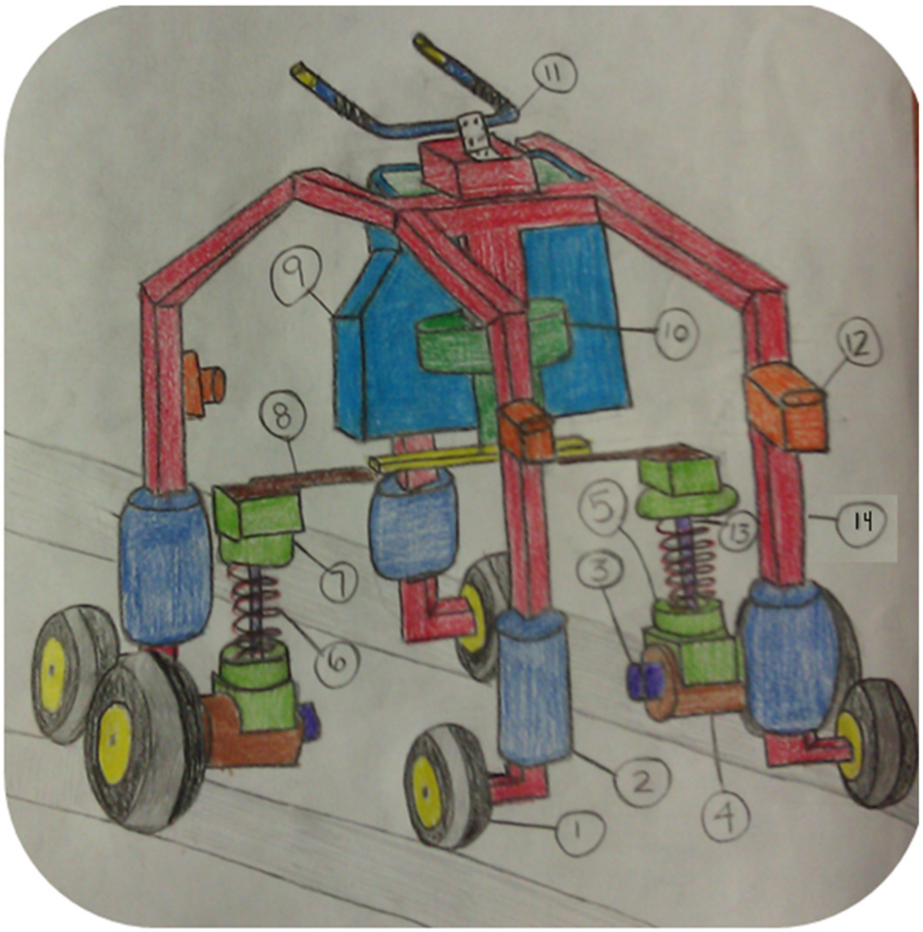
10) Steering Motor
11) Spring Driven Handle
12) Laser Sensor
13) Spring Dampers
14) Frame

Concept 3
Pros/Cons



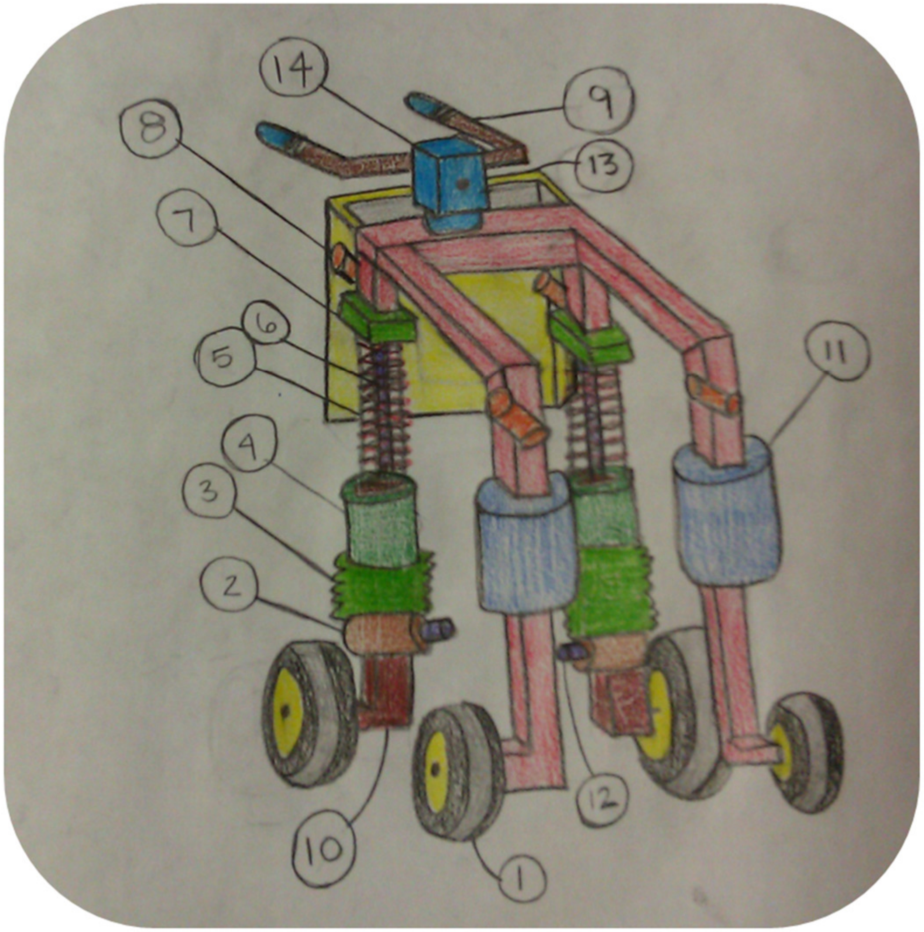
Pros:

1) Maximum payload
2) Durable, solid frame with added supports
3) Good Outdoor Use
4) Active Suspension

Cons:

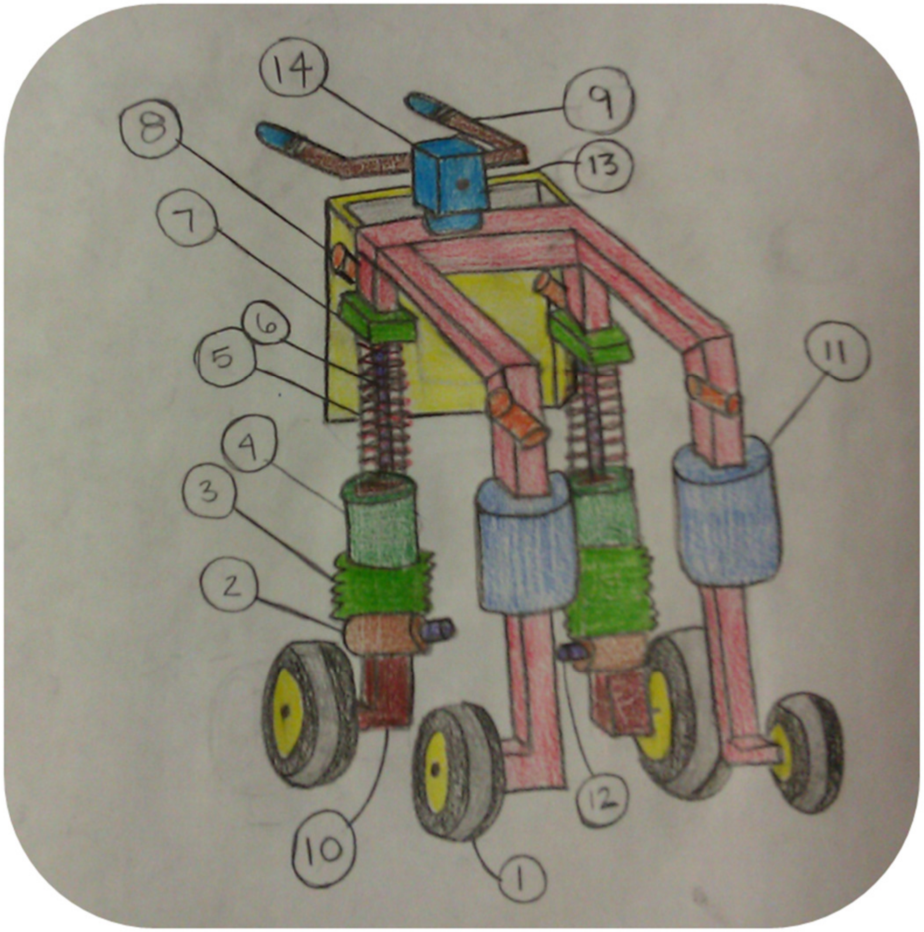
1. Bulky Frame
2. Fragile Components
3. Heavy Structure
4. High Cost
5. Foreign to User

Concept 4 Design



1) Caster Wheel
2) Driving Motor
3) Rotary Connections
4) Steering Motor
5) Spring
6) Damper
7) Spring Housing
8) Laser Sensors
9) Force Plate Driven Handle
10) Driving Wheel
11) Caster Suspension
12) Motor Encoders
13) Basket / Electronics
14) Laser Sensor

Concept 4 Pros/Cons



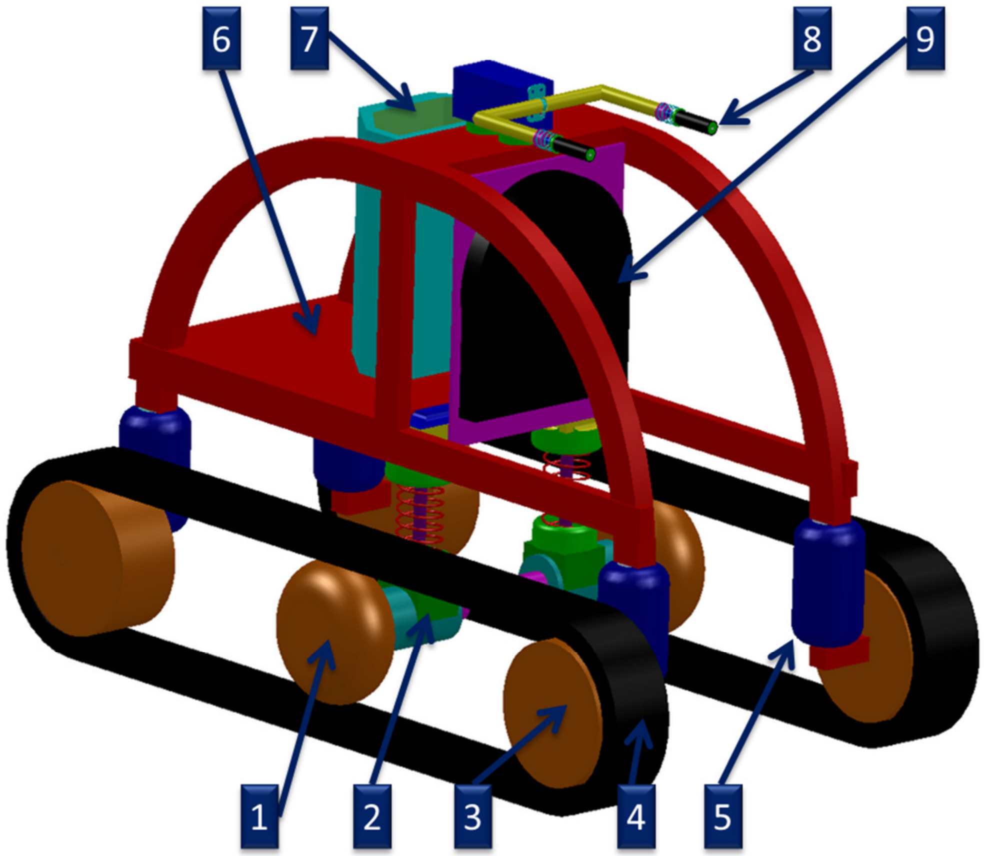
Pros:

1. Fast
2. Lightweight
3. High Indoor Use
4. Navigation System

Cons:

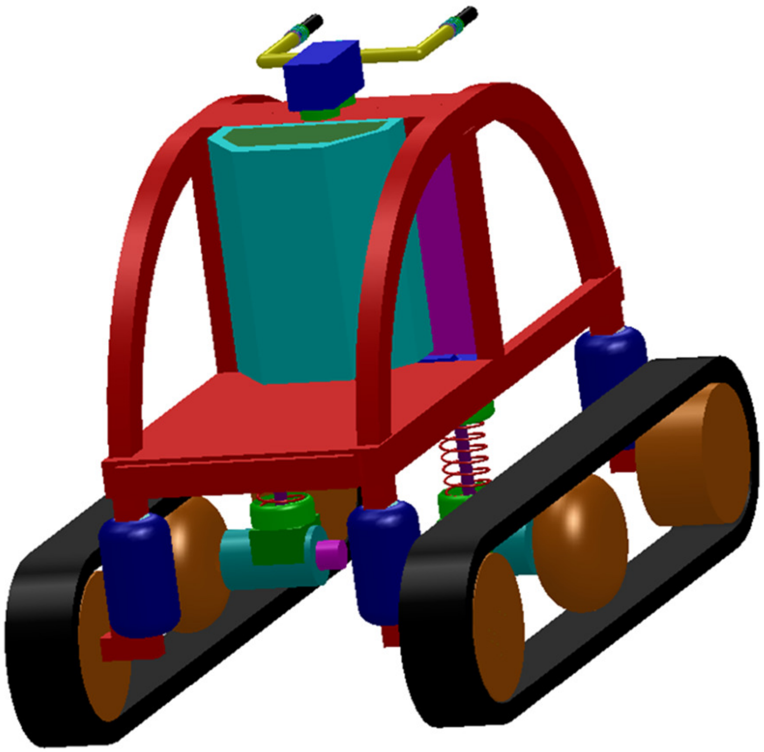
1. Minimal Payload Capacity
2. Fragile Components
3. Limited Outdoor Use
4. Low Demand
5. Expensive

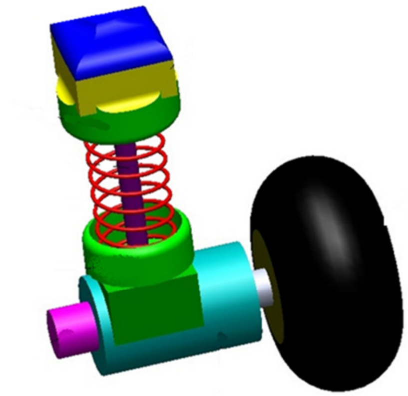
Concept 5 Design

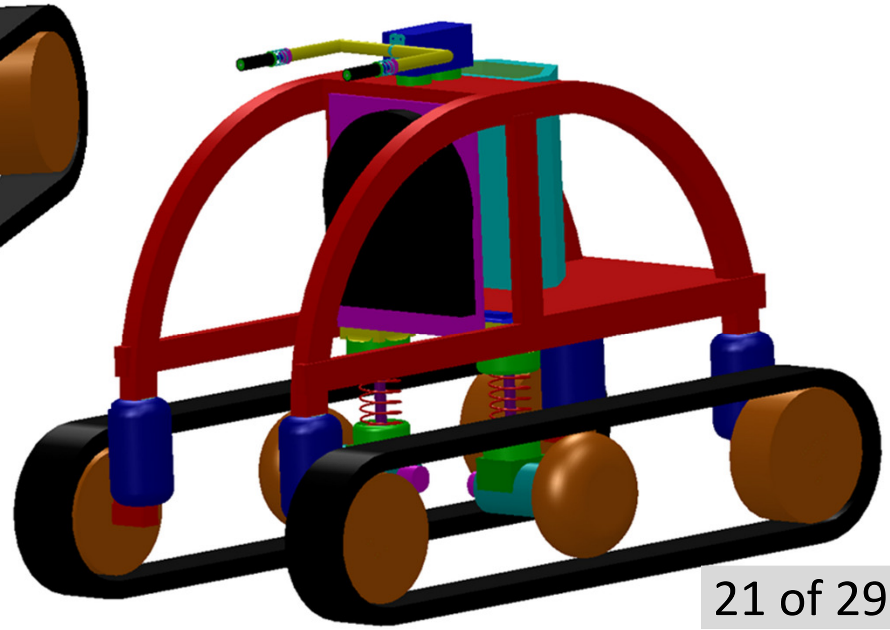


1) Driving Wheel
2) Driving Motor
3) Track Suspension and Tension Wheel
4) All-terrain tracks
5) Suspension
6) Front storage
7) Basket / Electronics
8) Spring Input
9) Foldable Seat

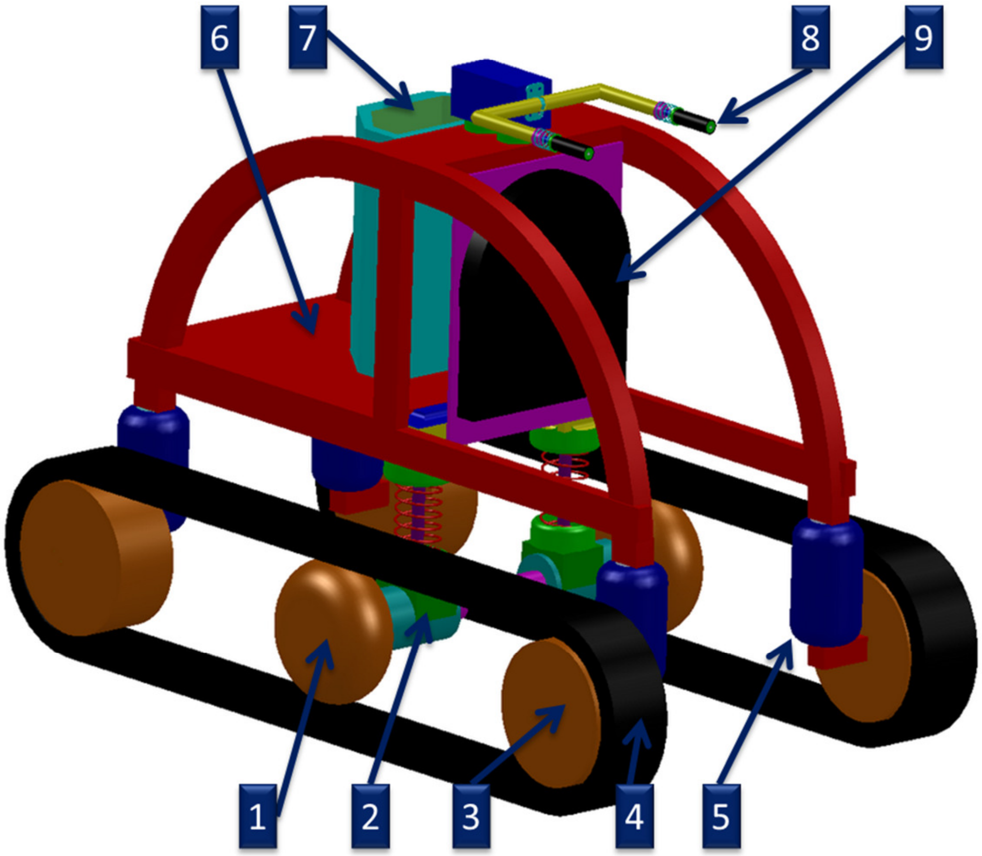
Concept 5 Design







Concept 5 Pros/Cons



Pros:

1. Great Outdoor Operation
2. Active Suspension
3. Riding Capability
4. Large Payload

Cons:

1. Minimal Indoor Operation
2. Passive Dimension Adjustments
3. Expensive
4. Heavy

Criteria Weighting

Criteria

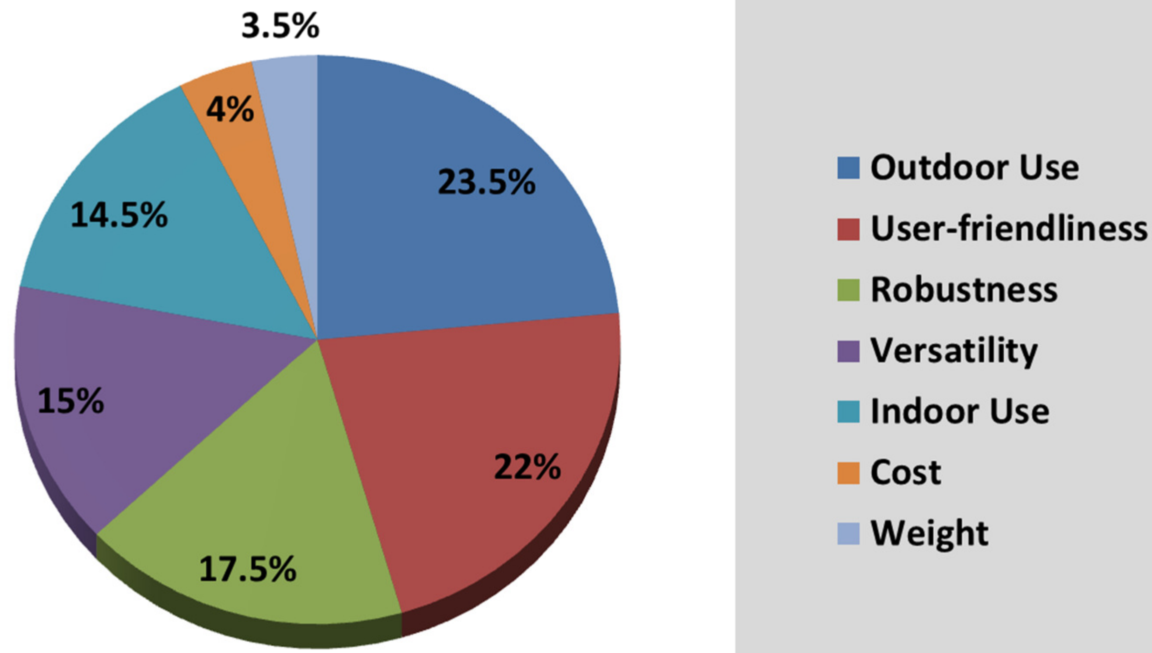
- **Versatility**
- **Robustness**
- **User-friendliness**
- **Indoor operation**
- **Outdoor operation**
- **Cost**
- **Weight**

Criteria Weighting

	Versatility	Robustness	User-friendliness	Cost	Indoor	Outdoor	Weight
Versatility	1.00	3.00	0.50	4.00	0.33	0.25	5.00
Robustness	0.33	1.00	0.50	4.00	3.00	1.00	5.00
User-friendliness	2.00	2.00	1.00	5.00	2.00	1.00	5.00
Cost	0.25	0.25	0.20	1.00	0.25	0.20	2.00
Indoor	3.00	0.33	0.50	4.00	1.00	0.50	4.00
Outdoor	4.00	1.00	1.00	5.00	2.00	1.00	5.00
Weight	0.20	0.20	0.20	0.50	0.25	0.20	1.00
Sum:	10.78	7.78	3.90	23.50	8.83	4.15	27.00

Rank	Definition
5	greatly more important than
4	substantially more important than
3	somewhat more important than
2	slightly more important than
1	same importance
1/2	slightly less important than
1/3	somewhat less important than
1/4	substantially less important than
1/5	greatly less important than

Criteria Weighting

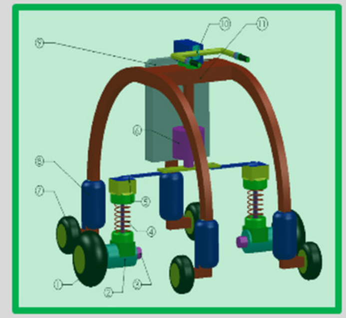


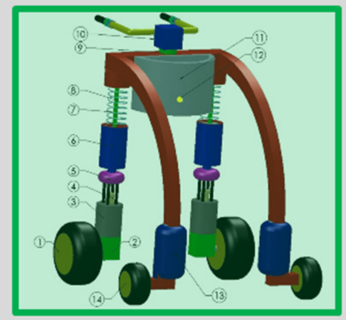
		Concept 1		Concept 2		Concept 3		Concept 4		Concept 5	
	Weight	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted
Versatility	0.15	3	0.454	5	0.757	3	0.454	3	0.454	3	0.454
Robustness	0.175	4	0.699	3	0.524	5	0.874	3	0.524	4	0.699
User-friendliness	0.22	3	0.670	4	0.894	2	0.447	5	1.117	3	0.670
Cost	0.04	2	0.086	2	0.086	1	0.043	1	0.043	1	0.043
Indoor	0.145	3	0.429	3	0.429	2	0.286	3	0.429	1	0.143
Outdoor	0.235	4	0.926	3	0.695	3	0.695	2	0.463	5	1.158
Weight	0.035	2	0.066	3	0.099	1	0.033	4	0.132	1	0.033
		Sum:	3.331		3.483		2.832		3.163		3.200

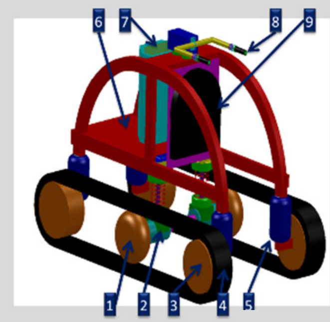
Conclusions

- **Based on preliminary investigation, further detailed analysis will be applied for:**
  - **-Concept 1**
  - **-Concept 2**
  - **-Concept 5**

- **Concepts 1 and 2 are considered moderate to good across all selection criteria**

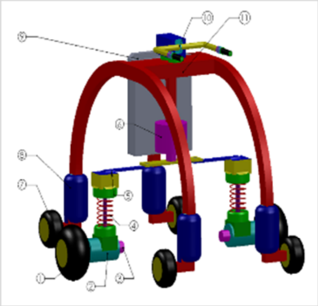


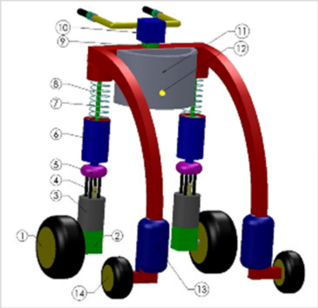


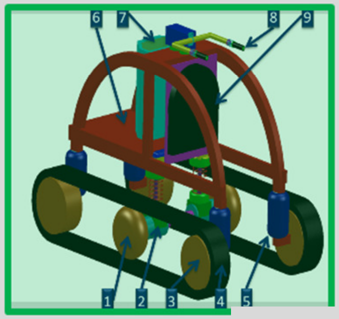


Conclusions

- Based on preliminary investigation, further detailed analysis will be applied for:
    - -Concept 1
    - -Concept 2
    - -Concept 5
- Concepts 1 and 2 are considered moderate to good across all selection criteria
- Concept 5 optimizes the highest ranked criterion (outdoor operation)







Questions?