Project Proposal

Team 9- Go kart for Nathan Lamb

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Executive Summary

This project focuses on designing and assembling a custom go kart specialized for an 11-year old boy with multiple developmental disabilities including Spina Bifida, cognitive challenges and slight autism. The custom go kart is to accommodate the client’s limited limb dexterity and coordination. This poses a challenge for customary go kart steering and foot pedal devices that are used today. To overcome this difficulty, two methods of operation were presented. One method is to allow the client to control steering and acceleration with a joystick located on the left armrest attached to the passenger side seat. The second method would consist of a wireless remote control that could be used by the client’s parents or friends to control the go kart. Implementing both of these methods into the design would be optimal and allow the client to have control of the vehicle while providing the necessary safety precautions of a kill switch remote control.

To further ensure proper safety measures, the go kart would be battery powered as requested by the client. In addition, the dual passenger go kart would have 5-point harness systems and adjustable seating areas to accommodate the clients’ growth and allow for a variety of passenger sizes. Additional head and trunk support would be provided to accommodate the clients’ head positioning and limited trunk strength. The client also wishes to use the go kart on gravel and grassy areas therefore a multi-terrain, shock absorbent model will be used. The final product would be a more customized and user-friendly go kart than the commercial products that are now available.

1. Introduction

1.1 Background

The client, Nathan Lamb, is an 11-year-old male with spina bifida, cognitive challenges, and slight autism. He is slightly small for his age: approximately 45 inches and weighing 44 pounds. Nathan is also developing scoliosis and has a tendency to position his right arm to the right side of his head. Nathan is unable to properly use his
right hand, which limits his motor control, and has poor trunk strength. Spina bifida is a birth defect that involves the incomplete development of the spinal cord or covering. The symptoms of spina bifida can range from none to severe neuromuscular disabilities such as paralysis. Nathan attends Mystic Middle School and is tutored by a recent UCONN Special Education graduate. He has been seen by his physical therapist since age three. The therapist has been seeking to find a one-armed drive mobile stander for Nathan to use to enhance his classroom experience. Nathan also travels to Columbia weekly for craniosacral therapy treatments at Crossroads Physical Therapy. Our young client is your typical 11-year-old boy who loves excitement and an adrenaline rush.

1.2 Purpose of the Project

The client’s only source of mobility has been his manual wheelchair. This project will provide him with more enjoyable mobility at higher speeds. Additionally this customized go kart will bring to him a higher standard of recreation and allow him to better socialize with his fellow peers and parents. The client is not able to use the current commercially available go kart due to his disabilities. Therefore, an alternative, patient-specific customized design is essential. The seating support and control method should account for the clients’ unique growth and improvement. This is impossible to accomplish with the standard commercial go kart. In summary, the purpose of the project is to provide our client with a safe and enjoyable form of mobility that would give him a new level of recreation and allow him to better socialize with his peers and family.

1.3 Previous Work Done by Other

1.3.1 Products

There are a number of other products and projects with similar objectives and designs. A couple designs were implemented through the Biomedical Engineering Department at the University of Connecticut. In 2009, an NSF sponsored go kart was built for a child with severe cerebral palsy (Figure 1). This design consisted of a number of different controls including a joystick, a wireless remote control, and a steering wheel. The cost to manufacture this go kart (labor excluded) was $7,300. Our design would be
similar in size and shape of the frame and chassis. In 2010, a go kart was designed and produced for a boy with cerebral palsy and global apraxia. It was also battery powered and had two sets of controls. One was a remote control that would be responsible for the steering, speed and breaking. The second control consisted of jellybean style buttons. These were used for the client and required little force to depress. Also, all the buttons provided power to the vehicle while steering. This design has many features that would also be favorable to our clients needs. The cost of production of this go kart was approximately $3,000.

Figure 1: NSF-sponsored senior design go kart, University of Connecticut 2009.

Other similar projects at the University of Connecticut were the “E-Racer” projects in 2001 and 2008. The project from 2008 incorporated a steering wheel that was controlled by switches thereby allowing the go kart to be operated by hand. Both projects cost a rough estimate of $2,500.

An early production of a go kart for children with disabilities was the 1994 NSF sponsored “Electra-Scooter” in Buffalo, NY. The design was essentially a platform on wheels that was pre-programmed to move linearly or in a circular path. The drivers’ wheelchair was secured onto the platform and the driver was left with little responsibility in controlling the vehicle. This project only cost approximately $870.
There are also a number of commercial go karts that are available on the market today. These include Berg Go karts and go karts produced by Mobility4Kids, which manufacture vehicles of various sizes, speeds and physical limitations. Mobility4Kids in particular has go karts with different control types including: joystick, steering wheel, and switches. The go karts are electrically powered and reach up to 7 mph. These go karts range from $5300 to $7000.

1.3.2 Patent Search Results.
As of today, there is a patent on the market for the control system of a go kart for people with disabilities. The 2002 design was patented by Keith Alan Roberts and incorporates the three critical controls of driving; throttle, brake and steering into one steering column. The design is crucial because it allows for the single-handed control of the vehicle that is necessary for many people with disabilities. The design also incorporates a kill switch that can be used to completely shut off the machine if there is any loss in control.

2. Project Description

2.1 Objective
The following limitations/preferences must be met by this project based on preliminary interviews with the client:
1. There should be an extensive seat system to accommodate Nathan’s problems with posture.
   A. Bucket seat similar to what Nathan currently uses to ride in cars
   B. Seat must incorporate a five-point harness to provide support.
   C. Both seats must be adjustable to accommodate Nathan’s growth as well as a large range of friends and family
   D. Seat must have leg straps to ensure his legs do not protrude outside of the chassis.
   E. Seat must have adjustable arm rests to accommodate Nathan’s growth as well as posture.
2. There should be two methods of control.
   A. Joystick control for the client.
      I. Must be dual axis control with directional and speed control.
      II. Must be located on the left arm rest.
   B. Remote control
      I. Must be dual axis control with directional and speed control.
      II. Must contain a reliable kill switch.
      III. Must have a large range because it will be used in a large field.

3. Go kart must be battery powered and rechargeable
4. Go kart must have a roll cage.
5. Go kart must have extensive suspension capable of operating off-road
   A. Go kart must have off road tires.
6. The vehicle must have on-board control to choose remote control or on-board joystick control.
7. Steering must be controlled electrically.
8. There must be a top speed of approximately 20-25 mph.
9. A motor controller must be able to deliver the appropriate voltage to the motor, corresponding to the appropriate speed.

2.2 Methods

The majority of the components will be custom built and assembled by the team members with the exception of the chassis. We will custom fit the frame and other necessary components to the chassis. The go kart will be dual-passenger so the chassis and frame will be measured to seat two adults. The driver seat will be tailored to the clients’ size and limitations, recognizing his growth and development in the future. The complete assembly will include mechanical, electrical and software collaboration. The design will comprise of a control system, governed by software, which will convert physical human input through an electrical interface that will influence the mechanical components, resulting in the desired output. The various systems are described in more detail below.
Mechanical

There are a multitude of essential components critical to the mechanical system of the vehicle. These components include the drive train, chassis, harness, seat, suspension, roll cage, steering, and motor control. There are several mechanical components that are not commercially available and must be custom built in order to suit the physical needs on the client. The following subsections provide more detail on the mechanical components mentioned above.

Drive Train

The drive train is the collection of components that produce power and ultimately causes motion. The drive train consists of the engine that feeds into the transmission which provides the speed and torque that is transferred to the driveshaft. The driveshaft then propagates the torque to the differential which transmits the rotations through three shafts and to the wheels. Our drive train will have battery power input; therefore, a brushed DC electric motor will be used to create the motion. To allow the DC motor to navigate both forward and backward, an H bridge integrated circuit will be incorporated in the source design. Necessary gearing to transfer the power from the DC motor to the driveshaft will also be incorporated. Ideally, as requested by the client’s parents, the go kart will be operated at approximately 20 mph. Since the power output of the DC motor depends on the motors’ input voltage, the motor controller is necessary in delivering the desired power to translate to the desired speed. Careful control of the input voltage is a crucial part of the design because it allows a gradual increase in the speed, thus assuring the client’s safety. The DC motor that we suggest for the requested speed is a 4.5 hp.

Chassis

The chassis is a pre-assembled component purchased online from Northern Tool and Equipment, which was the base successfully used by the 2010 group. The chassis will weigh approximately 250 lbs. and will have front and back tire sizes of 16 x 6-6 (in). However, off-road tires will be added to optimize the functionality in the desired application. The chassis frame dimensions (L x W x H) are 72 x 43.5 x 47.25 in. The battery, motor, and associated materials will be installed behind the seat, thus providing
the power and torque solely to the rear axle. The front of the chassis will have the proper components to turn the front wheels applicably. The front of the chassis will have proper shock absorbent bumpers to resist any impact that could potentially damage electric components. A suspension system will have to be installed in the chassis to allow for off-road driving.

**Seats**

The seat is a critical element in the safety of the client. The client will be prone to whiplashing forces and other possible incidents such as crashing and rolling over. It is imperative that the seat accommodate the physical disabilities of the client and be a great mode of protection. The seat will be similar to a car seat/bucket seat that the client usually uses when riding in cars. The seat will accommodate the 5-point harness system and also protect the client’s physical disabilities. The seat will have neck support, helping to prevent whiplash and to protect the shunt in the client’s cranium. Due to the client’s weak body trunk, the seat will have to offer body support. Adjustable arm rests will be incorporated into the design, allowing the client to find a comfortable resting position for driving.

**Harness**

A 5-point harness system will be installed on the right hand side (passenger side) where the client will be operating. This system will provide the client optimal support and safety. The affix will be connected to groin support along with two straps around the waist and one over each shoulder. There will be additional support for the client’s head to limit movement that could lead to injuries.

**Suspension**

Installing a suspension system on the go kart is essential for not only comfort as the go kart travels over turbulent terrain, but also vital for the driver to remain in control of the vehicle. The go kart’s dual suspension system will mimic a rhomboid style, which consists of four wheel independent suspension. Each wheel will have a mechanical adjustable shock, consisting of a coiled spring, attached to the wheel and the frame of the
go kart, acting as shock absorbers. The mechanical adjustable shock will have 2.5 inches worth of compression, accommodating a load of 500 pounds. The suspension system will allow for the wheels to be touching the ground for the maximum amount of time possible over road and field terrain.

**Roll Cage**

To ensure the safety of the client, a roll cage is a necessity in the design. The go kart that would be used for the chassis has a roll cage welded to the chassis. The pre-welded roll cage spans the length of the car, welded to the front-most part of the frame beyond the steering wheel and welded to the back-most part of the frame behind the wheels. The width of the roll cage also spans the width of the go kart and is wider than the stock seats installed into the go kart. This significantly provides more safety to both passengers. There is ideal head clearance for the client, with the roll cage being 47.5 inches tall. The stock kart has cross bars that are connected to the chassis and the roll cage, aiding the driver and passenger in staying in the vehicle. Slight modifications may be made to the roll cage to allow for mechanical and electrical components. A cushion will be added to the cross bar for less impact when the driver or passenger go through turns.

**Electrical**

**Motor Controller**

The motor controller uses Pulse Width Modulation (PMW) to deliver an electrical signal to the motor based on a predetermined series of pulses. The supply voltage is constantly turned on and off based on the inability of the load to respond quickly enough for the motion to be significantly affected. This is a very good way of conserving power by reducing heat dissipation. The duty cycle is a quantity measuring the ratio of on time to the given time interval. Therefore, as the operator pushes the joystick forward or the pedal down, the duty cycle is increased, delivering more power to the motor. More power delivered to the motor translates to higher speeds.
**Steering System**

Two methods of steering must be implemented. The joystick will be mounted to the left armrest of Nathan’s seat, allowing ample comfort while Nathan is controlling motion. The remote control will contain horizontal and vertical controls; horizontal controls will navigate left and right and vertical controls will control speed.

Similar to previous projects, a gear motor will be used to supply power to the rack and pinion system. The pinion spins and converts the angular motion to linear motion along the rack when the user would like to steer. This causes a rotational motion of the front axle, leading to the desired steering. Since the steering must be controlled by joystick and remote control, a linear encoder transducer must encode position to allow the proper amount of steering to be implemented. A reduction in the gear ratio in the rack and pinion system allows for the operator to change direction quickly and easily.

**On-board Control Panel**

The on-board control panel must have three control components: remote controller/ joystick selection switch, on-board kill switch, headlight control, and the arm rest controller. In order to activate the remote controller instead of on-board controls, it must be switched on in the go kart. There will be a light emitting diode (LED) that will turn on when the remote control mode is activated. Both forms of the kill switch will shut off power to the driving motor, ensuring the safety of passengers.

**Remote Control**

Typical remote control cars operate at frequencies in the radio range (i.e. usually 27 or 49 MHz). Because the client would like to operate the go kart in large, open fields, the range of the controller must be maximized. The radio signal will be transmitted from the controller to a receiver located on the go kart. As the signal is received, it is converted to dual-tone multi-frequency (DTFM) tones and sent to a PIC microcontroller, where the selected electrical systems are activated or disabled.

The remote controller will have five control components: speed control, direction/steering, remote kill switch, forward/backward control, and headlight control. Since the controller must be able to activate the brakes during forward control, a separate
mode must be implemented so that down on the vertical controller corresponds to brake control.

**Arm Rests**

Upon request of the client, the arm rest controller will move the arm rests of the client up and down. Arm rests at a higher position will prevent Nathan from slouching, improving his posture. To allow Nathan to use the go kart continuously while he grows, these arm rests must be adjustable. A small DC brushed motor will drive the arm rests up and down.

**Joystick**

The controlling joystick will be mounted directly to the left arm rest to ensure Nathan will have constant access. Since the go kart is partly designed for Nathan to become comfortable with joysticks controls on electric wheelchairs, the joystick will be similar to electric wheelchair designs. As the joystick handle is moved along the two axes of motion, a different output voltage is present at the corresponding lead. This design is based on integrated potentiometers within the joystick. The vertical axis will control speed and braking, while the horizontal axis will control direction.

**Software Control**

All input electrical signals will be processed by a programmed PIC microcontroller. The microcontroller will be programmed in assembly. The controller will be responsible for processing electrical inputs and outputting the proper electrical response to control mechanical components. Two continuous main loops will be needed: one to control normal driving situations and one to monitor kill switch inputs. The only way that the primary loop will be terminated is if one of the kill switch inputs is activated. The kill switch will immediately deactivate voltage to the driving motor, ceasing motion.
3. Budget

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4. Conclusion

Living with a disability presents many challenges in and individual’s life, especially in a child’s life. These challenges are both physical and emotional, ranging from inability to control individual movement to feelings of isolation, being different and being left out. A go kart will not only provide a thrilling time for the client, but will also help to regain some independence and experience something that other children his own age can encounter without limitation. A go kart with two seats allows for a great bonding experience, enabling the client to have friends visit and share an enjoyable ride. Even if the passenger is the client’s father, the go kart will present valuable bonding time between them.

Furthermore, a go kart modified to the client’s needs presents a method for the client to learn lifelong skills. A joystick similar to that of an electric wheelchair will replace the driver’s side steering wheel, providing an opportunity for the client to develop his motor function to one day control an electric wheelchair. The ability to control a go
kart with a joystick will more than prepare him for the independence and control of an electric wheelchair, a large developmental step that the client’s physical therapist believes he is prepared to handle.

At first glance, the go kart may appear to be a costly endeavor for the client. After researching and budgeting components for such a project, a budget has been set to $4000. This value compares to other non-modified go karts on the market, reflecting the conceivability and the affordability of the project. The modifications and the adjustable driving components for future use alone would increase the commercial price, making this project unique and desirable to other children with disabilities.

Although this go kart is an approach to meeting some of the challenges the client may face, it is essential that the safety of the client is not compromised. The safety components of this go kart separate it from other designs on the market. The seats will have to accommodate his physical conditions such as his weak trunk and fragile neck while keeping him secured in the vehicle. A five-point harness will keep him strapped into the go kart and the roll cage will have to encompass both the driver and the passenger. The go kart will have to have custom suspension, a design component enabling him to ride around and experience less turbulence. The go kart will have custom bumpers, protecting the client from dangerous forces if he were to hit an object with the go kart. The most important and novel safety features of the go kart reside in the controlling mechanism. A remote control will be able to control the go kart from a distance in case of emergency. Both the remote control and the dashboard will be equipped with an engine cutoff switch, adding another element of safety, originality, and control over the go kart. There is no other go kart on the market that offers so much control, safety, accessibility, and affordability while reaching above and beyond the client’s ideal specifications.
References


