GRYPHON PRESENTS

AUTOMATED NAVIGATION FOR POWER WHEELCHAIR USERS

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INTRODUCTION

For people with disabilities who are unable to propel a wheelchair manually, the advent of the power wheelchair (PW) revolutionized mobility. Nowadays, users can steer, accelerate, and brake with no more than the flick of a finger on the joystick.

However, for a large number of individuals with mobility, sensory, or cognitive impairments limiting manual dexterity, major navigation and mobility problems impair the ability to achieve their dreams.

UI TECHNOLOGY HAS PLATEAUED

Sophisticated new user interfaces (UIs) have allowed power wheelchair users with more severe impairments to still operate their wheelchair, but only with great difficulty. Due to the physically and mentally demanding nature of these alternative UIs, users suffer more readily from muscular and mental fatigue, multitasking challenges, environmental hazards, and difficulties with both gross and delicate navigational adjustments.

The rate of UI improvement and innovation has slowed exponentially and provides little hope for the future of severely impaired PW users. The only solution is to **bypass the need for constant interaction with a UI**.

SMART NAVIGATION RELIEVES USER BURDEN

By connecting a personal computer, UI equipment, 3D scanner, LEDs, and other devices mounted on the PW with powerful cloud computing services and software with navigational algorithms, the power wheelchair becomes a self-navigating personal electronic vehicle (PEV). This system would take over the burden of navigation by automating navigational decisions and commands. Without the need for manual steering, the PW user is relieved of stress and is free to multitask.

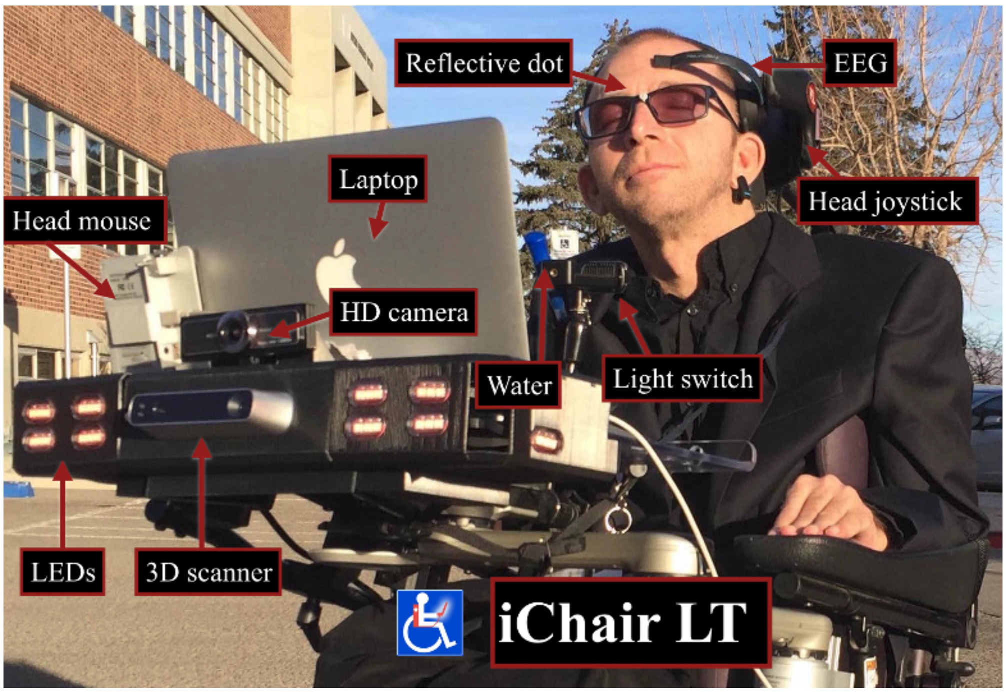
Better yet, as more data is gathered by the 3D scanner over time, the smart automated systems of such a PW would improve in accuracy and functionality, just as would a user performing manual navigation.

The iChair will be the first power wheelchair to bring together all these systems, and the potential impact on individuals with severe disabilities is significant in terms of mobility, livelihood opportunities, and quality of life in general. The iChair also implicates a future of PEVs that automate travel and other tasks for increased user convenience, productivity, and safety.

USER INTERFACE IMPROVEMENTS WON'T SOLVE THE PROBLEM

The most fundamental obstacle PW users face is finding a suitable input method. Most power wheelchairs are steered by joystick or button controls. Users unable to walk due to obesity or injury, instability, or lack of endurance, of the lower half of the body generally have no problem operating these.

However, in addition to difficulty walking, users with more severe disabilities may find joysticks or buttons challenging at best, and in many cases impossible to employ. Users with such conditions as cerebral palsy, Parkinson's or ALS suffer from reduced dexterity and strength, while quadriplegics and amputees may be entirely unable to operate conventional controls.



All PW users face increased threat of certain environmental hazards as compared to non-wheelchair users, such as uneven ground that can result in tipping over, collision due to spaces not made to accommodate wheelchairs or people not trained to look out for them, etc.

No current or developing UI solutions promise to significantly improve these problems any time soon. All depend heavily on the user's compromised motor skills, and every method besides joystick is inherently awkward to operate.

UIs have been developed to enable more challenged power wheelchair users to navigate their PW, but each has its downsides.

TOUCH

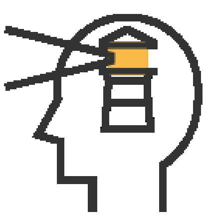
Some PW users who suffer from decreased manual dexterity are still able to operate touchscreen applications. Such applications are increasingly widespread, and the elderly of the near future will likely be comfortable with such controls. On the other hand, this method is still difficult for most users who are unable to use a joystick.

VOICE

For PW users without manual capability, voice controls are an option. Through applications on a PW-mounted computer, the user can navigate by voice command. The downside is that control speed is limited by the time required to speak a command, a slight delay in processing time, and occasional inaccuracy in interpreting the commands. Many users may also suffer from speech impediments.

COMPUTER VISION

The most common version of this is for the PW user to employ a HeadMouse system. A wheelchair-mounted camera emits infrared photons that reflect off reflective tape adhered to the user's hat or glasses. Combined with KeyStrokes software, the user is able to operate a computer by head motion alone. Other methods include pupil tracking and head tilt, but these are less reliable outdoors and require camera positioning close to the user's eye.



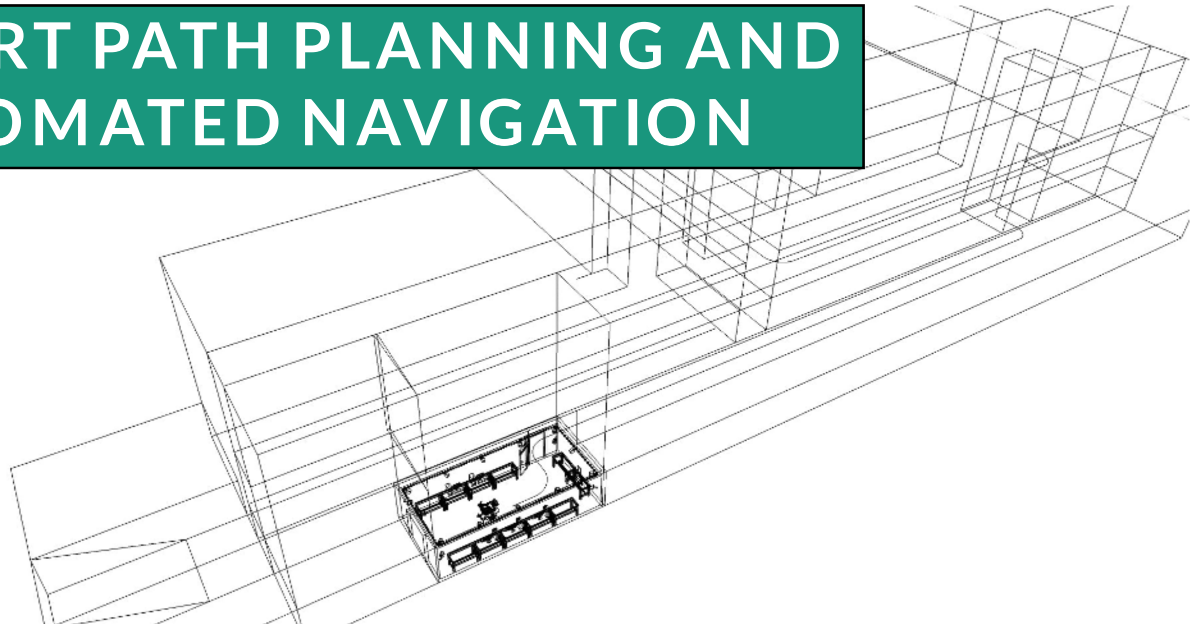
ELECTROENCEPHOLOGRAPH (EEG)

In development. The PW user's thoughts are essentially interpreted via electroencephalograph. In theory, PW operation is already possible using a binary switch, but distinguishing better between thought commands is necessary for finer movement control.

Each of these methods may cause the PW user to suffer to a greater extent from problems joystick/button users already face – namely, difficulty with delicate maneuvers, muscular and mental fatigue, and reduced multitasking ability.

The best solution would allow a more capable automated navigational system to take over – and that's where the iChair comes in.

SMART PATH PLANNING AND AUTOMATED NAVIGATION



Rather than have PW users make individual commands for every wheelchair movement through difficult-to-use UIs, the ideal PW would minimize the need for user input by automating as much of the navigation process as possible. By integrating several core technologies, the iChair achieves the ability to plan routes and take over many movement commands on behalf of the PW user.

Smart path planning and autonomous navigation require a global 3D map, external sensors, decision-making software, and some minimal user input. The PW user only needs to toggle a few options or give a some primary commands for the iChair to find the optimal route and travel to a specified destination – with no further movement commands from the user.

Existing maps may be pre-loaded into the laptop mounted on the iChair, but at present, most routes are unmapped, or at least not sufficiently mapped for navigation. Therefore, a PW user may need to map the terrain themselves to make future auto-navigation possible.

REAL-TIME 3D MAPPING

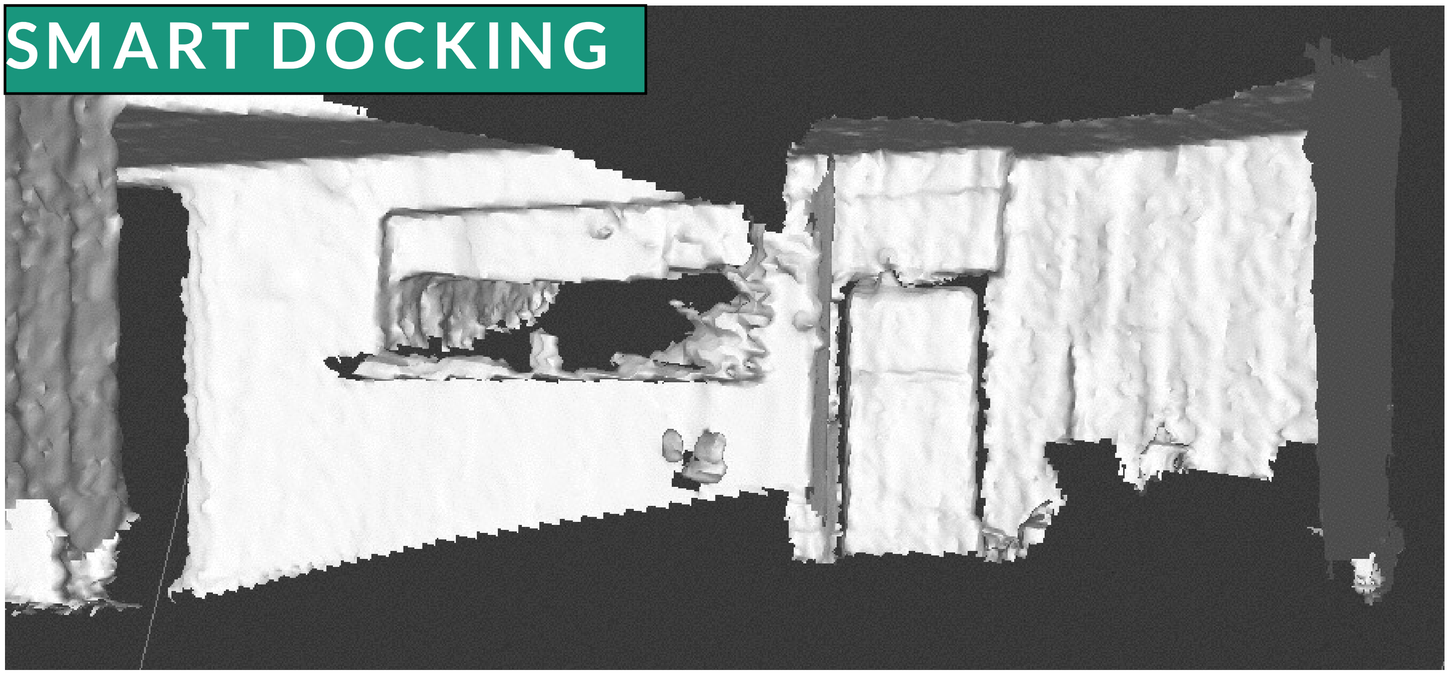
A fundamental technology in this process is a global 3D scanner mounted on the PW. When charting a new route, the PW user would activate the scanner and manually navigate through the route. The data recorded by the scanner is then processed to generate a 3D map of the area. Scanning a route over multiple passes can add accuracy to the map. This means the PW system would essentially be able to improve performance over time – a truly smart PW.

The volume of processing required to render scanner data into a 3D map is extensive and would be difficult for most PW mounted laptops to handle. A cloud processing service would therefor need to be available by subscription for users to upload data for processing into usable 3D maps.

Once the 3D map is downloaded from the cloud server, route planning algorithms would plan a route and automatically guide the PW to its destination. The only manual intervention necessary would be adjusting presets beforehand and initiating the autonomous navigation sequence.

This leaves the PW user free to relax and concentrate on other tasks, such as conversing with other pedestrians, while traveling. And while basic "hands free" functionality alone is a breakthrough, several system features extend auto-navigation to make it even more useful.

SMART DOCKING



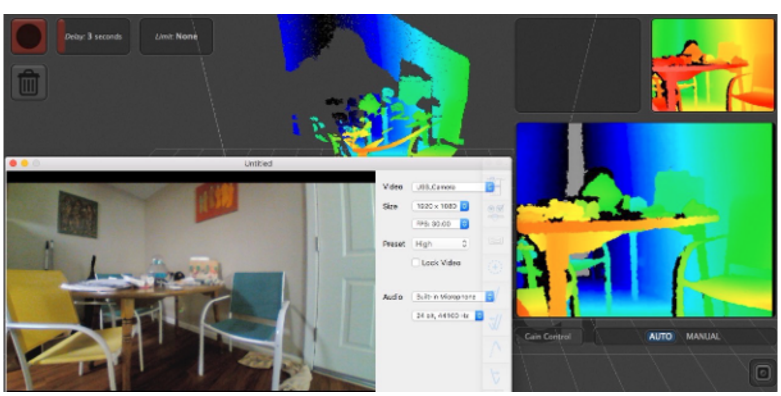
Charting routes over long distances relieves considerable strain and frees up resources for the PW user to do other activities while en route. But what happens when finer adjustments are needed in tight spaces? The more delicate the maneuvers, the more difficult it is for PW users with mobility, sensory, or cognitive impairments to perform them.

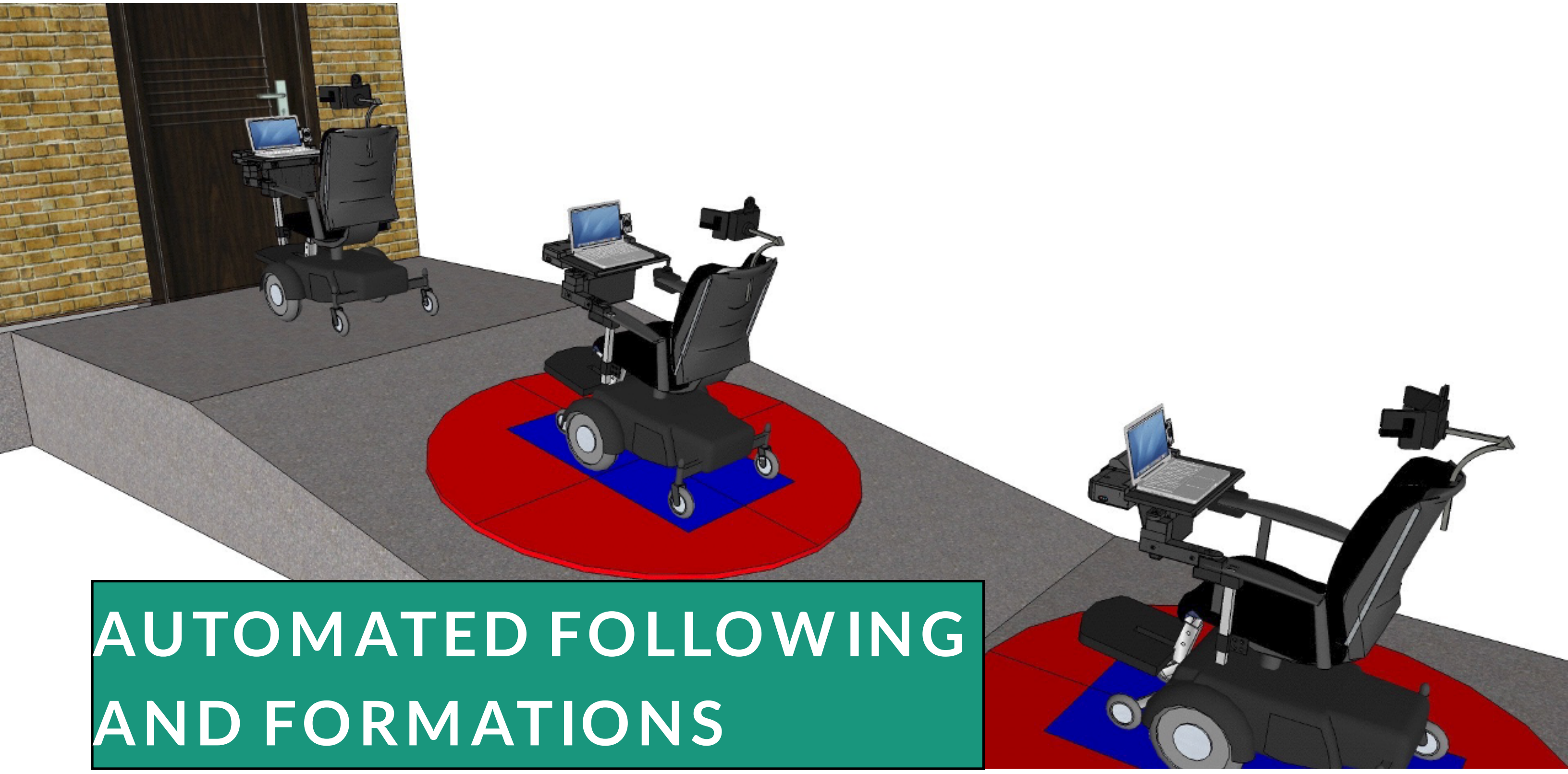
OUTSOURCE FINE MOTOR MANEUVERS

A natural extension of the smart route planning and auto-navigation features is smart docking. Smart docking allows the PW to take over more exacting steering tasks from the user to safely situate the PW at a table or other specified location.

With a solid wifi signal for access to the cloud processing service, the smart PW's 3D scanner gathers data on static objects to generate an increasingly accurate 3D map. Software on the PW's mounted laptop then employs algorithms to recognize objects, as well as potential docking points such as an empty space at a table.

The PW could then be commanded to auto-navigate into the docking point with no user effort required. Additional docking points could also be programmed and saved in the system to make parking at desks, in front of the television, near sinks in tight bathroom quarters, etc. simple and easy for the user.





AUTOMATED FOLLOWING AND FORMATIONS

A smart PW's auto-navigation capabilities would also allow for navigation relative to non-static points: in other words, following or moving in formation relative to other persons or objects. Automatic following requires two main elements: a leader and a formation.

ESTABLISH FORMATION

The leader could be a specified object that is recognized by the 3D scanner; it could also be a person or object emitting a signal for the PW to follow. The smart PW could automatically decide a formation, or could follow a preconfigured formation such as alongside, diagonally behind, or directly behind the leader.

Additionally, the PW could also be commanded to follow a leader along with other following PWs while maintaining a specified formation such as in a sidelong line, single file, V, inverse V, semicircle, inverted semicircle, or cluster.

PRACTICAL APPLICATIONS OF FORMATIONS

This feature has several special benefits. For one, a PW user can be guided through previously unmapped routes. Data gathering could be executed during auto-following so that a map could be generated and auto-navigation without a guide could take over the next time the route is chosen.

Certain environments lack sufficient static objects for the PW scanner to conduct accurate 3D mapping. For example, a city square or convention center crowded with people contains too many fluid dynamics to generate a map. In this case, a guide could lead a formation of PWs through the crowd.

In such a case, a single file formation would minimize route interference by the crowd. On the other hand, a sidelong line formation could maximize ability to comb an area, while a cluster formation would facilitate conversation among the group.

COLLISION AVOIDANCE AND OTHER SAFETY FEATURES

Of course, navigation in real life is different than in a model. Environments can change between mappings, and unexpected and dangerous events can occur. That's why the global 3D scanner and other sensors on the smart PW can be used to detect imminent objects or unexpected dangers and respond accordingly.

When sensors detect that an object is or will be too close according to range and trajectory parameters set by the user, the smart PW would execute measures such as providing visual or audio feedback or emergency stopping.

Automatic rerouting could also be set in the event that the interruption occurs during auto-navigation or auto-following. In the event that tipping, collision, or other such adverse events occur, the smart PW could send out visual and audio beacons, as well as emergency texts, phone calls, or emails to designated contacts.

These same proximity responses could be a hindrance in common situations such as docking, narrow doorways, tight passages, or crowds of people where the nearby objects are not actually a threat. The smart PW's collision avoidance features could be overridden or adjusted in various modes, such as docking or other exceptional situations.

CONCLUSION

Despite the great leap forward in mobility when the power wheelchair became widely accessible, many people with disabilities are still unable to use the conventional PW joystick or button steering systems. Users with various cognitive or upper body impairments must employ alternative UIs to operate their PW, each of which come with operational disadvantages compared to conventional steering.

The result is increased physical and mental fatigue, inability to multitask, and difficulty with fine navigational adjustments and avoiding environmental hazards. Even those PW users able to operate conventional steering suffer from these shortcomings to an extent.

KEY TAKEAWAYS

- Improvements in UIs have relatively little impact on the above problems. The answer is not to improve UIs, but rather to minimize dependence on them. Automated navigation would reduce the need for PW user input, especially when in a familiar setting that has already been mapped.
- Automated route planning and navigation could be enabled through a laptop and global 3D scanner mounted on the PW, cloud processing, and software with navigational algorithms.
- Functional extensions of this technology could include smart docking, auto-following in formation, collision avoidance and other safety features.

A MASS SOLUTION IS ON THE HORIZON

The iChair (intelligent power wheelchair) is a smart PW mounted with an integrated system of computer, scanner, sensors, and more that not only solves the issues associated with conventional steering, but also opens up new vocational opportunities for the PW user and smart vehicular possibilities for any person.

Improvements in 3D printing, cloud computing, and shifts in health insurance paradigms are resolving supply-side issues that have limited the affordability of a smart power wheelchair. Soon, smart PEVs will be available to level the playing field for people with disabilities.

Request more information to see how the iChair integrates diverse technologies to offer a complete auto-navigational solution for PW users by contacting info@gryphon.com.

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