

Review of Various Steering Systems for Unmanned Ground Vehicle

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ABSTRACT: The various steering systems used in all-terrain vehicles by various authors are reviewed in this paper. This paper presents the comparison of the different steering systems used, their application and limitation by various authors. The objective of present work is to study the different steering systems and to choose the best suitable steering system for an unmanned ground vehicle which would be used for military purpose.

KEYWORDS: All-Terrain Vehicle (ATV), Unmanned Ground Vehicle (UGV), steering systems, skid steer.

I. INTRODUCTION

An UGV can be integrated into a mechanized military force to increase combat capability while protecting soldiers in battlefield. Unmanned ground vehicles can be safely tele operated by soldiers at remote place. Unmanned ground vehicles can be employed in various scenarios, including inspection & disposal of explosive devices and mule applications. To maximize their effectiveness in this situations, unmanned ground vehicle must navigate cluttered environments in the presence of obstacles ideally at any speed. In the off-road context, the definition of obstacle could be anything that “obstructs” the motion of vehicle. It could be a rock, un-traversable slope, a tree or a cliff. To steer the vehicle with such obstacles is a major challenge. This requires unmanned ground vehicles to be highly capable of rapidly changing directions without a significant changes in speed, even in rough, outdoor terrain. Currently the major of unmanned ground vehicles under development are either tracked or Ackerman steered vehicles, neither of which generally exhibit high agility. Ideally unmanned ground vehicles would exhibit ability to move in any directions regardless of current position. This research suggest best suitable steering system for unmanned ground vehicles according military requirements.

II. LITERATURE REVIEW

Shailesh Lakkad (2003), reviewed different steering schemes that are used for robotic vehicles and battlefield robot vehicles such as XUV. Steering systems that are modeled and simulated are skid steering and four wheel steering.

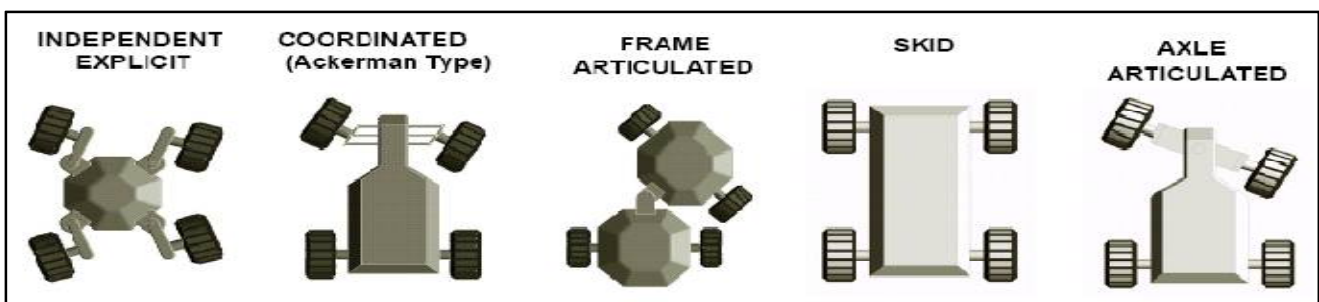


Figure1: Kinematics of Major Steering types.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 4, April 2016

He developed a skid steer model analytically and then performed dynamic analysis in ADAMS. From the results it is seen that skid steer causes excessive slip in tires thereby demanding more power input. At the same time, it allows zero point turn radius which is impossible in other classes of steering systems.

Following table shows a comparison of all types of steering based on different parameters.

	Independent Explicit	Coordinated Ackerman	Frame Articulated	Skid	Axle Articulated
Maneuverability	Medium/High	Medium	Medium	High	Medium
Mechanical Complexity	Medium	Medium/High	Low	Low	Low
Control Complexity	Low	Medium/Low	Medium	Low	Medium/High
Power	Medium	Medium/Low	Medium	High	Low
No. of Joints for steering	4	1	1	0	0

Table no1: Comparison of Different steering system based on different parameters.

A dynamic model is developed for a skid-steered robot ATRV-Jr considering lateral forces and longitudinal resistance. It is followed by a Matlab Simulation of the state variables. Results of the matlab simulation are compared to the results obtained from ADAMS simulation of the solid model of the ATRV-jr.

Benjamin Shamah (1999), performed experiment's using single vehicle that can exhibit skid & explicit steering while driving steady straight circles. The experimental results showed that power and torque for skid & explicit steering degenerate to equal values at infinite radius. This thesis argues that explicit steering draw significantly less power than skid steering during tight turning maneuvers. However for large radius turn, power draw during skid steering converges to the values observed during explicit steering.

Results were plotted as graph.

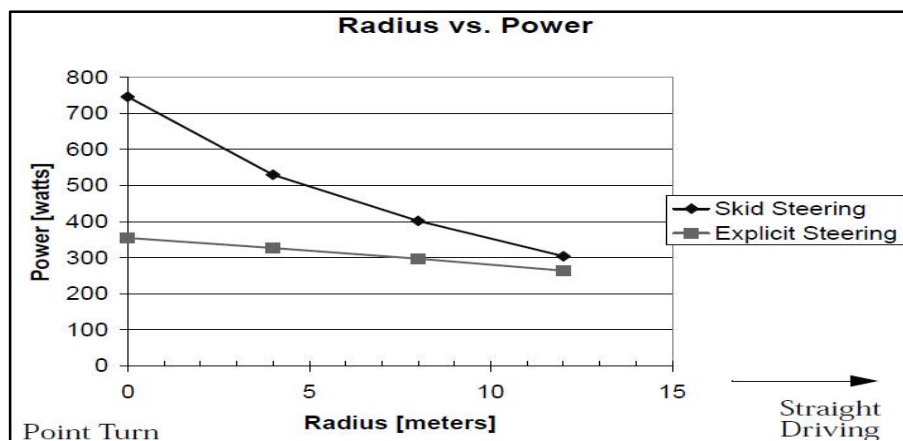


Figure 2: Experimental results of Radius vs. Power

Jesus Morales et al. (2010), studied power consumption of locomotion system of wheeled skid steer vehicles on hard horizontal terrain. Autonomous mobile robots have limited energy sources. Hence power consumption is very

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 4, April 2016

important issue for skid steer robotic vehicles due to relevant power losses associated to dynamic friction during turning. This work has proposed a simplified power consumption model for wheeled skid steer robotic vehicles on hard horizontal ground based on kinematics approach. This static model provides an estimation motor power consumption as a function of left & right side wheels' speeds. This model have been validated on the four wheel skid steer Quadriga mobile robot with four combinations of load and terrain type. Results have shown that this simple model closely resembles measured power consumption in test paths.

Wei Yu et al. (2010), developed dynamic model for skid-steered wheeled vehicles for general 2-D motion and linear 3-D motion. Skid-steered vehicles are often used as outdoor mobile robots due to their robust mechanical structure and high manoeuvrability. Sliding, along with rolling, is inherent to general curvilinear motion, which makes both kinematic and dynamic modelling difficult. An important contribution of this research is that unlike most previous research, these models were developed assuming a specific functional relationship between the shear stress and shear displacement and did not simply assume maximum value for the shear stress when an arbitrarily small shear displacements occurs. The dynamic models are validated using extensive experimentation and seen to yield accurate predictions of velocity and reasonable predictions of torque. One limitation of research is that the resistance term was developed using a constant linear and angular velocity assumption, and hence, although the models tend to give good results for linear and curvilinear motion with small acceleration, they tend to lead to prediction in accuracies when the vehicle has large acceleration during rotation.

B Maclaurin (2008), analysed the steering performance of 18t 6x6 skid steered vehicle and compared with that of a similar Ackerman steered vehicle. The basic properties of double differential mechanisms used for steering most modern skid steered vehicles are analysed. A tire model is used that enables the force characteristics at combined slip to be established from relatively small amount of pure slip data that are available for truck sized tires. A spreadsheet analysis is used for solving the equations of motion. This showed that the skid steered vehicle is generally neutral to oversteer whereas the Ackerman steered vehicle is understeer. The skid steered vehicle is also shown to require more power when cornering because of the power required by the steering mechanisms. B Maclaurin concluded that the skid steering has advantage for armoured military vehicles because it offers great internal hull volume and increased manoeuvrability, including the ability to perform a neutral or pivot turn.

Gao Shuang et al., discussed the skid steering applied to four wheel drive electric vehicles. In such vehicles, steering is achieved by differentially varying the speeds of the lines of wheels on different sides of the vehicle in order to induced yaw. He have chosen the unite semi-empirical tire model. The vehicle model has three DOF, longitudinal, lateral & yaw direction, irrespective of suspension. Induction motor was chosen as driven motor and controlled method is rotor flux field oriented vector controlled. A method of slip limitation feedback was used in simulation. The simulation results showed that the steering accuracy and manoeuvrability can be achieved and the traction controlled system can adjust the motor torque to satisfy different road conditions.

J. C. Fauroux et al (2007), experimentally proved the efficiency of skid steered 6x6 all-terrain vehicle can be substantially improved only by minor adjustments on the vehicle suspension. This method could be generalized to many types of multi-axle vehicles in order to improve their steering performance. The absence of any steering system on a vehicle is a guarantee of robustness and control simplicity but has the drawback of high power consumption during steering phases. With such a solution one can imagine an adaptive suspension capable of modifying normal force repartition on the wheels without changing neither mass nor payload repartition in the vehicle. This is currently done manually.

Tianmiao Wang et al. (2015), developed an analysis and experimental kinematics scheme of a skid steering wheeled vehicle based on a laser scanner

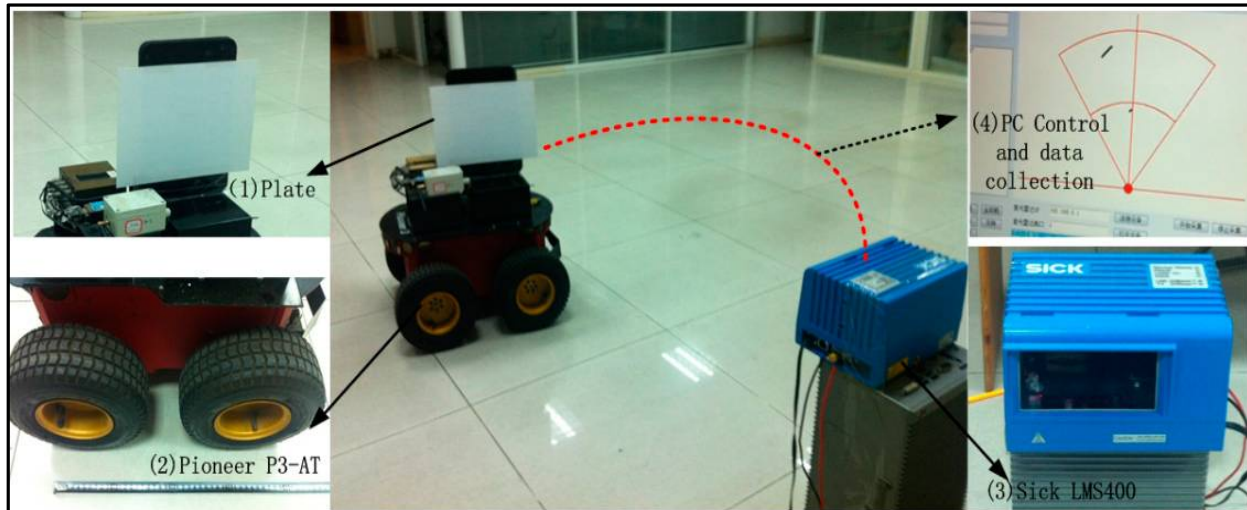


Figure 3: An overview of proposed localization method based on laser scanner.

The laser scanner based method experimentally drives the approximating function between ICR coefficients and a non-dimensional path curvature variable. The obtained function is validated on a sample path. It was shown that the proposed kinematics model estimated for a skid steering mobile robot improves the systems performance in terms of reduced dead-reckoning errors, with a smaller position error. This method is easy to operate without adding extra sensors or changing the vehicle mechanical structure and control system.

III. CONCLUSION

Unmanned Ground Vehicles have drawn considerable attention during the last years. Several systems are being developed independently, in many countries, at various universities, private companies & military research institute. UGVs started as simple remotely operated vehicles and now are moving gradually to the autonomous mobile robot domain. In any case, they can relieve humans from hard, difficult, dangerous, and delicate or may be boring tasks. Taking into account that research and development in the UGV area involves also military interest, it becomes evident that progress made may have advanced much more than what it is publically known.

The first step under consideration for upgrade of UGV is the use of proper steering system, global positioning and the addition of ultrasonic sensors and the relevant software's, offering local navigation and obstacle avoidance capabilities. Further steps may involve communications upgrade, addition of various sensors and even the installation of some kind of weapon system having in mind mainly the task of patrolling and protecting the base.

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ISSN(Online) : 2319-8753
ISSN (Print) : 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 4, April 2016

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