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Studies on Affecting Factors of Wheel Slip and Odometry Error on Real-Time of Wheeled Mobile Robots: A Review

D. Vidhyaprakash, A. Elango

Abstract**—**In real-time applications, wheeled mobile robots are increasingly used and operated in extreme and diverse conditions traversing challenging surfaces such as a pitted, uneven terrain, natural flat, smooth terrain, as well as wet and dry surfaces. In order to accomplish such tasks, it is critical that the motion control functions without wheel slip and odometry error during the navigation of the two-wheeled mobile robot (WMR). Wheel slip and odometry error are disrupting factors on overall WMR performance in the form of deviation from desired trajectory, navigation, travel time and budgeted energy consumption. The wheeled mobile robot's ability to operate at peak performance on various work surfaces without wheel slippage and odometry error is directly connected to four main parameters, which are the range of payload distribution, speed, wheel diameter, and wheel width. This paper analyses the effects of those parameters on overall performance and is concerned with determining the ideal range of parameters for optimum performance.

Keywords**—**Wheeled mobile robot (WMR), terrain, wheel slippage, odometry error, navigation.

I. Introduction

THE robot is an electromechanical machine, and the WMR in this study is one type of mobile robot. The wheeled mobile robot has rolling wheels with extensive mobility capabilities to maneuver within its environment. Overall performance and mobility of the WMR is relative to its ability to accurately sense and appropriately react to its environment. Wheeled mobile robots are used to perform various tasks and in a variety of workspaces such as medical service, military surveillance, space exploration, forests, construction, and material handed safety purpose in airports. In real time application, the WMR has been faced with some disadvantageous factors which are affecting the operation, such as wheel slip, odometry error, and vibrations. This paper deals with wheel slip and odometry error. Wheel slip is the relative motion between a wheel and the terrain surface. Wheel slip is generally given as a percentage:

$$\text{Slip}(\omega r-v)/v$$

where, ω is the rotational speed of the wheel, r is the wheel radius, and v is the vehicle speed.

The most important tasks of mobile robots are to arrive at the target location. WMRs with a simple structure can move quickly on flat and hard ground; however, they cannot pass through uneven or soft terrain. However, in many practical applications, such as navigation on outdoor, slippery or uneven, irregular surfaces, the no-slip assumption is not satisfied. As a matter of fact, slip is required to generate traction force at the contact point that is responsible for the motion of the WMR. It is possible to optimize the traction force, and therefore, maneuverability of the WMR can be improved by controlling the magnitude of the wheel slip. It may also generate instability in motion, which should be prevented. Wheel slippage can result in a considerable waste of power and time, and actual wheel ground interaction needs to be considered in order to improve the robot's movement. There is increasing interest in mobile robots capable of traversing uneven terrain without wheel slippage, as a considerable level of energy is consumed when WMR's experience wheel slippage, draining the robot's battery. Wheel slippage can also result in odometry error, as well as uncontrolled motion.

An odometer, which is a measurement method of wheel rotation as a function of time, is used by some robots, legged or wheeled, to estimate their position related to a starting point. If the two wheels of the robot are joined to a common axle or body, relative to pervious orientation can be determined from the odometry error measurement on both rear wheels of a two-wheeled mobile robot with a single wheel fitted at the front, which is also known as a caster wheel. The variation of positions and orientations of the robot has to be compared to its current position relative to the starting position. Odometry error (OE) can be treated as an output response and expressed as a function of parameters, namely payload (L), speed (S), diameter of wheel (D), and thickness of wheel (T). To find out the variation in position and orientation of the robot with respect to its starting point (p) across a given span of time, linear distance DR and DL of each wheel traveled (computed from the number of ticks of the encoders and diameter of the wheel) and wheel base (W) are substituted in the following equation and the new orientation(R) in radians is calculated as:

$$R=P+(DR-DL)/W$$

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Establishing the position of the WMR is considered an important task, as the exact position is required for maximum control and path planning in order for the robot to reach the desired target. The position of the WMR is calculated usingtheodometryreadingfrom the wheel's encoder and is mostly used for simple and economical execution is to determine its relative location.

II. Literature: Wheel Slip

Wheel slippages are related to the wheel and surface contact area. The coefficient of friction for dynamic contact is lower and has less traction. Slip is generally given as a percentage of the difference between the rotational speed (wheel speed) of the wheel and vehicle speed. A literature study of wheel slippage in WMRs mostly concentrated on stability and path planning. This study takes into consideration different parameters including payload, speed, and geometry of types of wheels for mobile robots in determining of wheel slippage. Very few researchers have considered the effect of these parameters in the determination of relative localization by using wheel slip and odometry error.

A. Effect of Payload

The weight carrying capacity represents the payload only and does not represent the weight of the WMR. Based on payload range, [1] has shown that the incremental of payload of a WMR has reduced the wheel slip and tottering of the robot and structure.

On rigid terrain, the large size wheel and great amount of onboard battery mass had to give the maximum traversable ability. This result was found by Udengaard and Iagnemma [4]. Whenevera particular range of load distribution wheeled was applied to WMR it had the effect of controlling or reducing wheel slippage. This result was found by Ravikumar and Saravanan [5]. The minimization of the traction force results in decreased travel time. The traction force was related with the load of the system in the experiment undertaken by Oyadiji and Ayalew [7].Whenthe payload on the front wheel axle increased, traction and climbing abilities on all terrains improved, having the effect of controlled wheelslip, as determined by Bruzzone[10]. One of the prototype wheeled mobile robots controlled its climbing ability through the even weight distribution of the motor on each axle. This was proven by [11] that a change in wheel weight improved the climbing ability of the robot,as well as slightly improving tractionon low inclination. This experiment was taken from the specific "VENTRA" (Two wheeled mobile robot)model, as shown in Fig. 1, weighing 1.2 kg, with a distance of 120mmbetweenthe two wheels (W), it has a maximum speed ofupto 200mm/s.

The experiment was carried out in an indoor environment where it was observed that increasing payload considerably reduces wheel slippage and results in smoother movement within a particular payload range (0.8kg-1kg),as shown in Fig. 2.

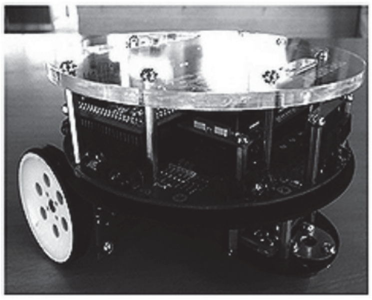

Fig. 1 Ventra wheeled mobile robot ([5] International Journal of Scientific and Research Publications, Volume 3, Issue12, December 2013 1 ISSN 22503153)

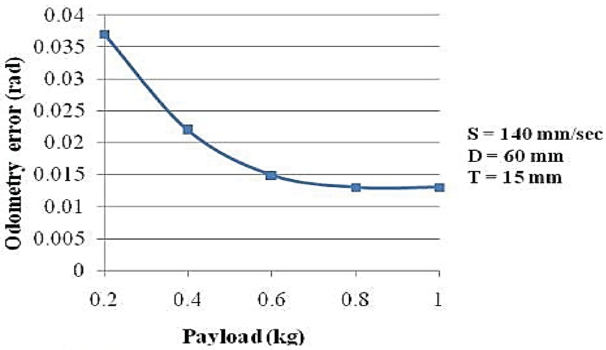

Fig. 2 Odometry error vs. payload ([1] International Journal of Scientific and Research Publications, Volume 3, Issue 12, December 2013 1 ISSN 22503153)

The above graphical representation indicates how increased load variance can control wheel slip. This is proved by Ravikumar and Saravanan [13]. Increased payload considerably reduces wheel slippage and tottering of the robot which leads to lessdeviation of the WMR. The mobile robot rough terrain control (RTC)for planetary exploration system commands increased torque to the rear wheel, which has a much higher load, this effect has been determined by Dubowsky[12]. The split and fit trailing arm (SFTA) suspension mechanism system controls the load and results in 50%to60% reduced wheel slip. This effect has been proved by Appala and Ghosal [16].Changing the position of the load mainly affects the location of the global center of mass and the whole moment of inertia of the pendulum as presented before. Thisexperimenthasbeen determined by Khaled et al. [17]. The increased force with less increment of mass has to maintained the frictional force and limit slippage by yiliang jin[28].

B. Effect of Robot Speed

Speed is related to the velocity (m/s) of the mobile robot. When the two wheeled differential drive robot wasoperatedin real-timepractical conditions at slower speed, as seen in the graphical representation,the recommended range of speed 140mm/sec to 160 mm/sec. In this range of speed, the WMR experienced very minimal wheel slippageandlesswheel distortion, as discovered by Ravikumar and Saravanan [1].

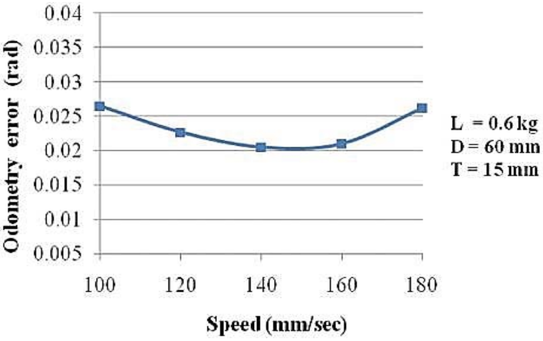

Fig. 3 Odometry error vs. speed ([1] Issn22780149www.Ijmer, Vol, 3, January 1,2014)

Wheel slippage increases when a particular range of velocity starts to be applied [5]. The desired velocity profile is converted to a suitable body frame velocity based on the robot's current position and orientation, andactual wheel velocity can be determined via the odometry. Howevermore sophisticated methods are required to estimate wheel slippage, as determined by Udengaard and Lagnemma [3]. The system of the sliding model control can actually improves the vibration phenomenon of mobile robots. This enables for a stable control function within short and limit period time on the tracking control of the position and speed of the WMRs. It can also promote efficiency of the system's control response speed, as discovered by Mao Lin Chen [6]. The specific model of WMR determines the optimum condition for better relative positioning. Within the optimum parameters, a speed range of upto144mm/sec is suggested as the ideal condition for better relative positioning of a two-wheeled differential drive robot, and results in limited wheel slippage and hence odometry error. An effect studied by Ravikumar and Saravanan [13].

The robot performance has improved successfully on its traverse time at low speed condition and could be traverse on obstacles. The ballistic behavior was formed in high speed of robot models as well as formed the wheel slip. This result has been produced by Udengaard and Lagnemma [18]. Once slip ratio become larger than the boundary value of 0.2, the control system will be decreased the slip ratio value by reduced the rotational velocity of wheel; however, the traditional formula of slip ratio cannot be applied directly to the robot when the height is changed because it is affected by the relative velocity between the body and wheel. This is founded by Xilun and Kejia [15]. The steer angle and the wheel velocity along the forward (x) axis of the wheel frame can be determined from the x component of wheel equation in wheel coordinate, then the drive velocity (around the axle) can be computed by using the wheel radius. Surface contact parameters were tuned to minimize wheel slip in the dynamic simulation. Minor disagreements between the physical experiment and simulation share due to unmolded peculiarities in Zoe's construction, such as hysteresis in the roll average mechanism. The work has been produced by Kelly and Seegmille [20]. The overall effect is that the wheel's velocities are matched more tightly even in the presence of internal and external disturbances. It should be also noted that the proposed control strategy does not require any additional sensors other than wheel encoders and steer potentiometers that are commonly available in most robots. Reina finds this [21]. The high wheel slip and loss of traction during this high-velocity maneuver. founded by Laura ray [22]. Wheel slip is fundamentally caused by forces acting on the vehicles founded by Forrest Rogers-Marcovitz[23].The traveling velocity of the robot had controlled to maintain a constant movement. Each active split offset caster module calculates wheel angular velocity required for the maneuver based on the kinematic control method of omni directional mobile robots. tested by Ishigami and Pineda [26]. Based on the fuzzy reactive navigation strategy of collision free and velocity control has controlled of mobile robots' motion on greenhouse environments by Mester and Gyula [29].

C. Effect of Diameter of Wheel

The wider wheel has been minimizedatground pressure. A large size wheel has significantly less compaction deviation from linear path. The advantage of large diameter wheel is ground clearance. Centre of gravity and small diameter of wheel advantage has some merits, and they required less torque to traverse the same speed with less weight. It was shown that the odometryerror is lesser when wheel diameter between 50 and 60 mm. The diameter of wheel should not be very high as well as very. The lesser and larger diameters of wheel lead to the possibilities for wheel turn at maximum speeds and jerks at slower speeds respectively which cause deviation from linear path, and this effect has been studied byRavikumar and Saravanan[1].

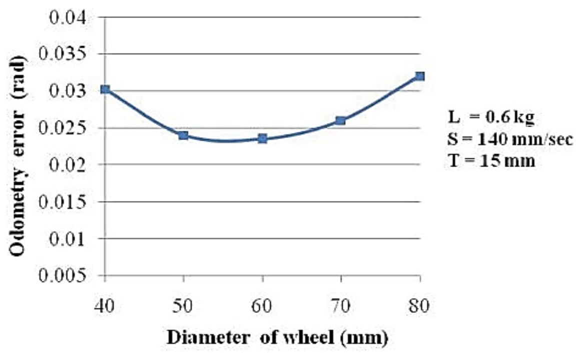

Fig. 4 Odometry error vs, wheel diameter ([1] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

The rear wheels of ROVER model robots wereslightlylargerto keep the proper contact with ground andfrontwheels climb on the step, while smaller diameter wheels wereprovided low performance due to closeness to ground casing links to interfere with the obstacle, and this effect has been studied by Debeshand Sen [2]. The wider wheel has been minimizedgroundpressure. A large size wheel has significantly less compaction resistance than a small size wheel.

A wider wheel was preferred to cancel the slip or reduce the slip of wheel for maximumtraversable distance, and this effect has been studied by martin UdengaardandLagnemma [4].The moderate range of perimeter of robot's wheel diameter is the useful maneuverability of wheeled mobile robot, since very low and very high value of wheel perimeter is not suitablefor proper odometry. This effect has been studiedbyRavikumar and Saravanan[5]. Based on confirmation of experiments for optimum condition of Load 1 kg, speed144mm/s,diameter of wheel60mm,thickness of wheel11mmof Ventra,two wheeled mobile robot has the optimum condition for the better relativepositioning such as minimum odometry error. The minimum odometryerrorcame from lowwheel slip of robot, and this is proved by Ravikumar and Saravanan [13]. The active split offsetcaster (ASOC) robot's position estimation based on traditional odometry methods may not beaccurate in rough terrain. This is due to wheel slippage that causes miscounts of wheel rotation. In particular, the ASOCdriveomnidirectional mobile robot experiences large wheel slippageduring sharp turning maneuvers. This is proved by Ishigami and Pineda [14].

D. Effect of Wheel Thickness

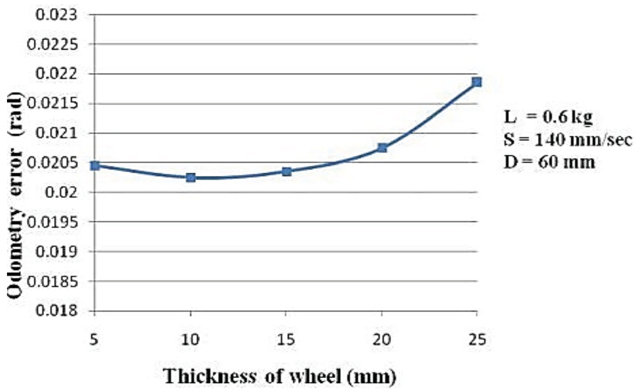

Fig. 5 Odometry error vs.wheel thickness ([1] ISSN22780149 www.ijmer,Vol,3,1,January 2014)

The contact between wheel and surface decided on the slippage, friction force. The thickness varied from 5 mm to 10 mm and further increased with the increase in thickness. So, it is evident that the minimum odometry error comes from the lowest wheel slip in the range 10-15mm. of thickness. The lesser contact area of wheel on the floor due to smaller thickness provides the accurate wheel base for the odometry calculation that leads to minimal slippage and also lowodometry error. This is proved by Ravikumar and Saravanan [1]. The rear wheels are slightly larger in diameter to keep proper contact with ground as and when front and middle wheels climb the step. This effect has been studied by Debeshpraan et al. [2]. Wheelterraininteractionforces were determined via a simple coulomb friction model. The terrain elevation was modeled as a zeromeantriangular zed mesh with elevation points possessed a standard deviation of σ. In initial simulations it was assumed that the robot possessed perfect knowledge of terrain inclination. Contact locations were determined by making a thin wheel approximation and finding the intersection are between the wheel and the local triangular mesh patches. This effect has been studied by Martin Udengaard and this is proved by Iagnemma [3]. The optimizations for the relatively deformable terrains (i.e., dry sand and snow) resulted in wheels with larger radii, but narrows width compared to those optimized for relatively rigid terrains. The large radii lead to decreased ground pressure and compaction resistance, while the thinner width leads to decreased wheel weight [4]. The lesser contact area of tyre on the floor due to smaller width provided the accurate wheel base for the odometrycalculation that leads to minimal odometry error. This is founded by Ravikumar [5].Based on confirmation of experiments for optimum condition of load 1 kg, Speed 144 mm/Sec, diameter of wheel 60 mm, Thickness of wheel 11 mm of Ventra two wheeled mobile robot has the optimum condition for the better relative positioning such as minimum odometry error the minimum odometry is come from low wheel slip of robot. This is founded by T. Mathavaraj Ravi Kumar [13]. Surface contact parameters were tuned to minimize wheel slip in the dynamic simulation. Minor disagreements between the physical experiment and simulations are due to unmolded peculiarities in Zoe's construction, such as hysteresis in the roll averaging mechanism; this is founded by Kelly [20].

III. Literature-Odometry Error

The odometry error is another one of the factor decided to move in proper stream line, odometry is a measuring method of wheel rotations a function of time (real time).The wheelslippage is created the bad odometry or odometry error. If the two wheels of the robot are joined toe common axles, or separate axle orientation of the center of single axle relative to the previous orientation. The odometry error result (oe) can be treated as output response and expressed as a function of parameters (payload, robot speed, wheel diameter, wheel width)

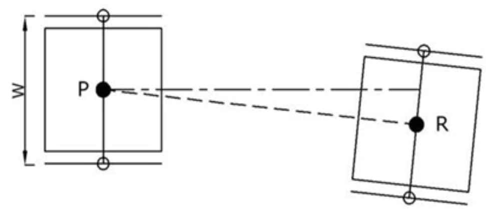

Fig. 6 Orientation of robot, p is starting position, r is current position, w is centre point of both wheels ([13] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

A. Effect of Payload

Whenever the increased a payload the odometryerroralso decreased. From the graphicalrepresentation the odometry error decreased with the increase of payload up to 0.8kg. Also it wasobserved that there was no significant change in the odometryerror could be lesser between 0.8kg and 1kg.

The increment of payload considerably reduced the wheel slippage and tottering of robot that leadsto less odometryerror. The work has been foundedbyT.MathavarajRavikumar[1]. In this case theRTC system commands increased torque to the rear wheel, which has a much higher load thanthe front wheel, resulting in increased net thrust. The dual criteria optimization remained interaction maximization mode for the majority of the travels. The moderate load is not allowed to wheel slip and odometryerror. The work has been finished by KarlIagnemma [12]. Wheel terrain contact locations were determined by making a thin wheel approximation and determinded the intersection arebetween the wheel and the local triangular mesh patches. It has been produced[3].While applied the articular ranges of load distribution apply on the wheeled mobile robot has to be controlled or reduced the wheel slippage and odometryerror, is proved in[5]. The proposed four wheels robot in order to maintainitsstability from the center of gravity changes due to any extraload. Each wheel has attached to thetip of a leg because in many cases, sufficient space is not available to set the leg and wheelseparately on the body of the robot. The proposed robot has four wheels in order to maintain itsstability due to the center of gravity. The changes due to any extra load, which can be seen in [9]. The specific model VENTRA two wheeled mobile robot is being the useful utilization. The Fig.1 is representing its detail and it self-weight is 1.2kg and thedistance between two wheels (W) is 120mm, the maximum speed is up to 200mm/sec.The robot wasdriven in an indoor environment as per the observation of experiment occur that the increasingthe payload considerably reduced the wheel slippage and given smooth movement within theparticular payload range (0.8kg to 1kg).

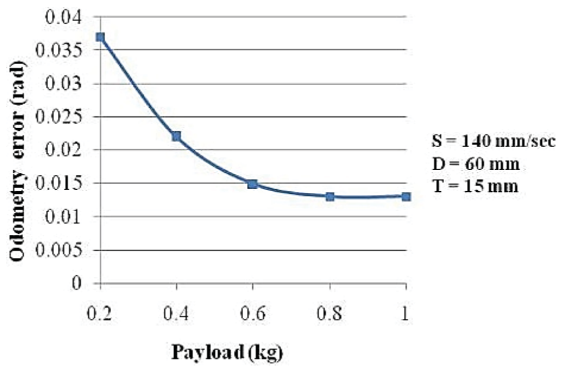

Fig. 7 Odometry error vs pay load ([1] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

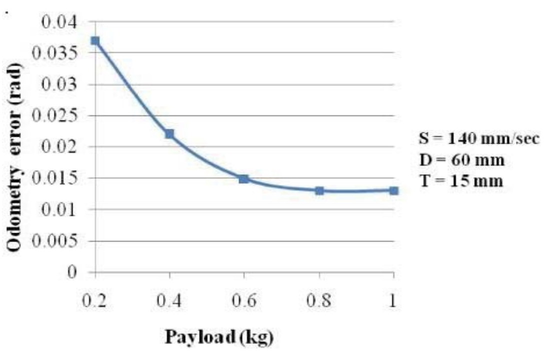

Fig. 8 Odometry error vs pay load ([1] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

The above graphical representation is presenting or indicating the detail of odometry. Control ascending of load variance. The work has been conducted by T.MathavarajRavikumar [13]. The increased in payload considerably reduces the wheel slippage and odometryerror, tottering ofrobot that leads to less deviation of WMR. When changing the location of the load mainly affect isthe location of the global center of mass and the whole moment of inertia of the pendulum as presented before. The work has been conducted byKhaledet al. [17].

B. Effect of Robot Speed

The speed factors are one of the important while speeds on the wheeled mobile robots that willbe generate some disturbance, the effect of disturbance is allowed the speed range, When therobot has moved with slower speed in partial conditions, the possibilities of wheel distortions, vibrations and wheel slippage are appreciably less which causes very minimal odometryerror, has been produced by Ravikumar. [1].

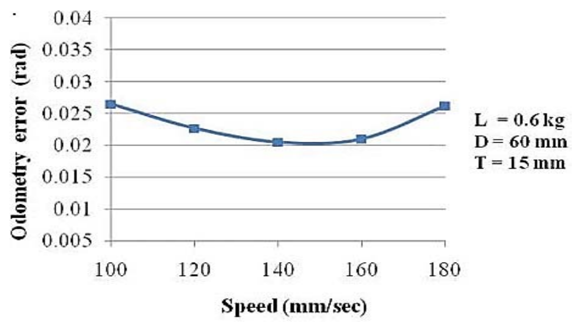

Fig. 9 Odometry error vs.speed ([1] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

The desired velocity profile is converted to a desired body frame velocity based on the robot'scurrent position and orientation. Actual wheel velocity can be determined via odometry. However,moresophisticated methods are required to estimate odometry error and wheel slip[3]. Fromtheodometryerror decreased significantly and startedtoincreaseaftercertain level. So, it has clearly understood that the error is minimal between 125mm/secand150mm/sec. When the robot was moved with slower velocity in practical conditions, the possibilities of wheel distortions, vibrations and wheel slippage are less which causes veryminimalodometryerror.

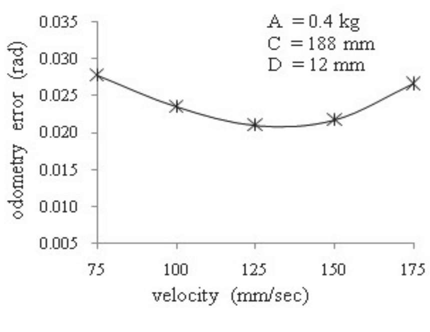

Fig. 10 Odometry error vs.velocity ([5] IJE TRANSACTIONS C; Aspects Vol, 27, No, 3(March2014)359366)

The diagram representing the normal level of the odometry (125mm/sec150mm/sec) error is not increased above has been produced by Ravikumar [5]. The system of sliding model control can actually improve the vibration phenomenon of mobile robots. It enables two wheeled mobile robots control to achieve stable control function within short and limit time on the tracking control of position and speed. It can promote the efficiency of system's control response speed. The work has been conducted by Chen [6]. Robot localization used the above odometry prediction (commonly referred to as dead reckoning) is accurate enough in the absence of wheel slippage and backlash. These effects are however largely reduced when the velocity is kept reasonably small and the number of backup maneuvers is limited. This is proved by De Luca [8]. The specific model of wheeled mobile robot is determination the optimum condition for the better relative position. In this optimum level of parameter is represent the speed range is 144mm/sec suggested to optimum condition for the better relative positioning of two wheeled differential drive robot, in this level odometry error is very low hence the motion is with in stream line. This is proved by Ravikumar [13]. The applied force or speed is activated on the particular area that reacting was the movement or deflection, determined by [17]. The wheel base area and speed of robots was decided the pose error of turning tracks. Found by Jung [19]. Large differences in the wheel velocities were produced with consequent, undesired increase in the amount of slippage, the slip was produced the odometry error, the orientation error was defined as dr-dl/w where dr and dl are the right and left side longitudinal displacement as measured by encoders and W is centre of both wheels determined by Giulio Reina [21]. Relative position or odometry estimation is extremely dependent on the measurement of robot's velocity founded by Amer [24]. A good initial pose estimate helps the localization algorithms to provide accuracy position by the range of speed. Founded by Lamoan [25], The slip-resilient sensor had captured the image processing hardware on the robot determined the speed and direction,it can be used in odometry system by Loan Doroftei[27].When the vehicle move towards the goal and the sensor detect the an obstacle,an avoided stategy and velocity control were necessary by Gyula mester[30].

C. Effect of Diameter of Wheel

From below graphical is representing the odometryerror decreased when the diameter of wheelincreased from 50mm to 60mm. It is clear that theodometryerror is lesser between 50mm to 60mm of wheel diameter. The diameter of wheelshould not be very high as well as very low for the reduction of odometryerror. The lesser andlarge distances (or) diameters of wheel leads to the possibilities for wheel turn at maximum speedsand jerks at slower speeds respectively which cause deviation from linear path. This is proved byRavikumar [1].

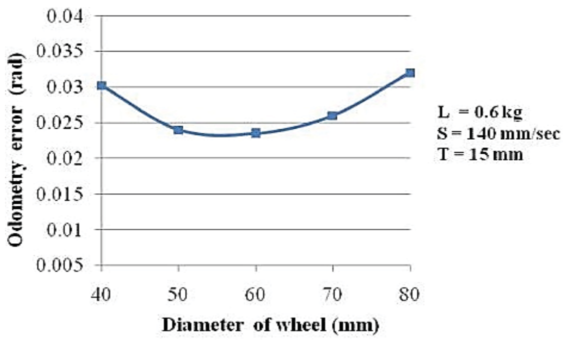

Fig. 11 Odometry error vs. wheel diameter ([1] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

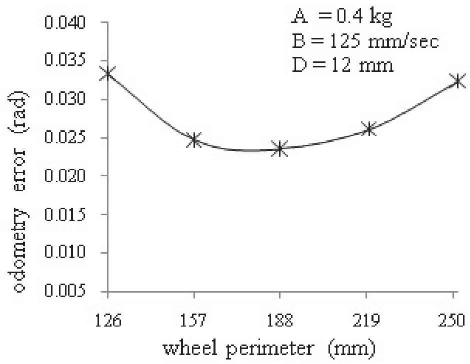

Fig.12 Odometry error vs wheel perimeter ([5] IJE Transactions C; Aspects Vol, 27, No, 3(March2014)359366)

The rear wheels of ROVER model robots are slightly large in diameter to keep proper contact with ground as and when front and middle wheels climb the step, smaller diameter wheels will provided low performance, due to closeness to ground casing links to interfere with the obstacle. The work has been produced by [2]. The odometryerror decreased when the wheel perimeter increased from 126 mm to 157 mm and increased when perimeter increased further. Itis clear that the odometry error is lesser between 157 to 188 mm of wheel perimeters. The wheelperimeter should not be very high or very low for the reduction of odometryerror. The lesserand larger perimeters of wheel lead to the possibilities for wheel turn at maximum speeds andjerks at slower speeds respectively which cause deviation from linear path.

Based on confirmation of experiments for optimum condition of load1kg, speed144mm/sec, diameter of wheel60mm, thickness of wheel11mmof VENTRA twowheeled mobile robot has the optimum condition for the better relative positioning such asminimumodometry error the minimum odometry is come from low wheel slip of robot. The work hasbeen conducted by Ravikumar [13]. The active split offset caster (asoc) robot'sposition estimation based on traditional odometry methods may not be accurate in rough terrain. This is due to wheel slippage that causes miscounts of wheel rotation. In particular, the ASOChas driven omnidirectional mobile robot experiences large wheel slippage during sharp turningmaneuvers. The work has been produced by Ishigami [14].

D. Effect of Wheel Thickness

The contact between wheel and surface are decided the slippage, friction force, thickness varied from 5 mm to 10 mm and further increased with the increase in thickness. So, it is evident that the minimum odometryerror seems to be in the range 10-15mm of thickness.

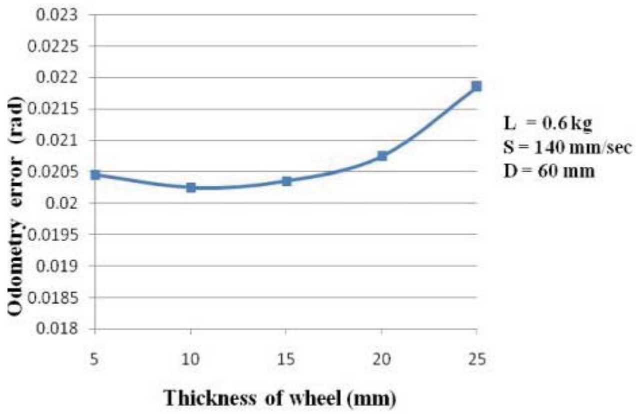

Fig. 13 Odometry error vs wheel thickness ([1] ISSN22780149www.ijmer, Vol, 3, 1, January 2014)

Lesser contact area of wheel on the floor due to smaller thickness provides the accurate wheelbase for the odometry calculation that leads to lowodometryerror. .Has been produced byRavikumar [1].Wheelterraininteraction forces were determined via a simplecoulomb friction model. Terrain elevation was modeled as a triangular zed mesh withelevation points possessing a standard deviation of σ. In initial simulations it was assumed thatthe robot possessed perfect knowledge of terrain inclination. Contact locations were determinedby making a thin wheel approximation and finding the intersection are between the wheel andthe local triangular mesh patches. this effect has been determined has been produced by Udengaard and Iagnemma [3].The optimizations for the relatively deformable terrains (i.e., dry sand and snow) resulted inwheels with larger radii, but narrows width compared to those optimized for relatively rigidterrains. The large radii lead to decreased ground pressure and compaction resistance, while thethinner width leads to decreased wheel weight. It was controlled by the WMR. Thiseffect has been determined by Udengaard [4]. There was a decreased in odometryerror,whenthetyrewidthwas varied from 4 mm to 8 mm and furtherincreased with the increase in width.

So, it is evident that the minimum odometryerror seems to be in the range 8- 12mm ofthickness.

The lesser contact area oftyre on the floor due to smaller width provided the accurate wheel basefor the odometry calculation that leads minimum error this effect has been determined byRavikumar [5]. Based on confirmation of experiments for optimum condition ofload1kg, speed144mm/sec, diameter of wheel60mm, thickness of wheel11mmof VENTRA two wheeled mobile robot had to be gave the optimum condition for the better relativepositioning such as minimum odometryis come from low wheelslip of robot. This effect has been determined by Ravikumar [13]. Surface contactparameters were tuned to minimize wheel slip in the dynamic simulation. Minor disagreementsbetween the physical experiment and simulations are due to modeled peculiarities in Zoe'sconstruction, such as hysteresis in the rollaverage mechanism, the work has been concerned by Kelly [20].

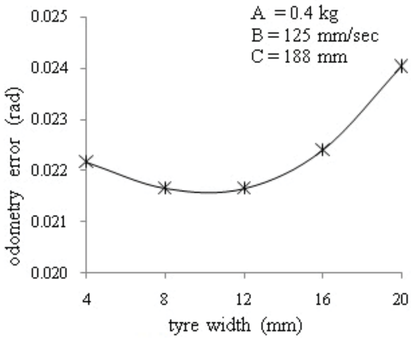

Fig. 14 Odometry error vs tyrewidth([5] IJE Transactions C; Aspects Vol, 27, No,3(March2014)359366)

IV. ComparisonWheelSlip with Odometry Error on Real Time of WMR: Summary

The wheeled mobile robot's wheel slip and badodometry are the mostly the affected factors on the robot's movement of differential two wheeled mobile robot. The both draw backs (slip. Odometry error) has beencreated some another indirect affectedparameters namely Jerk,vibration,pitch,yaw,roll movements etc. Here the analysis first about the wheel slippage of wheeled mobile robot and how to be reached the target with in the time and energy save condition. In casewheeled mobile robot's both wheels were affected in wheel slippage,also it not supported toanynavigation,if any one wheel was affected in the wheel slip at same time its navigation is also slowdown on any terrain or floor. The odometryerror is the one of the other an affected factor. The wheel slippage was creating the odometryerror. The odometry error was the different from the wheel slip because therobot'smovement were possible towards the target, but the odometry error was produced the uncontrolled streamline movement, hence the travel time, energy loss was more. From the above analysis the more time consume and energy losses were mostly come from the wheel slip and odometryerror on the time of navigation. But the wheel slip is most an affected factor in the real times of navigation of WMR to an achieved the target/goal, because the both wheels were an affected in the time of wheel slip it may not possible to move. But the odometryerror gave as the movement to WMR, so the target reachable may possible on the even or uneven surface condition. Thus the odometry error is not most an affected to reach the target/goal compared with the wheel slip factor.

V. Conclusions

The wheel slip and odometryerror of wheeled mobile robots is mostly an affected factor and considered as a direct affected factors to the robots performance. Especially the wheel slip lead to consume more time and more energy wastage of WMR compared with the time of odometry error. The direct affected parameters (Payload, robot speed, diameter of wheel, width of wheel) are much influenced on the WMR performance to produce the wheel slip and odometryerror. When an affected the most of all wheels of robot by the wheel slippage on the any surface/floor its performance werereduced suddenly. Its recovery may be difficulty (sea sand surface, lose soil) and also the bad odometry, jerk,vibration,pitching& yawing are possible to produce in the time of wheel slip. Hence the target reachable was not reliable. At the end of study the four main parameters (payload,speed,diameterofwheel, thickness of wheel) of WMR has been considered with reference and to the selection or recommend the range of parameters to make an innovation to the mobility performance (without slip, good odometry). It is the most significant condition to the overall system of WMR is reliability. Future trend in mobile robots was briefly suggested that both rear wheels may be connected withindividual axle and motor. In case a front wheel was much weight than rear wheels to be given and maintain its streamline motion control based onthe formula F=ma,(f-force,m-mass,a-acceleration)and the frictional force were acted on the apparent wheel contact area in order to stop the slippage and odometry error of the wheeled mobile robot. Also rear wheels were may be roll and keep in proper stream line, It may be a better than previous exist for high end application in outdoor units robots (military and floor utility tasks) especially low cost wheeled mobile robot.

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