



## SRI LANKA PATENT

To All to Whom These Presents Shall Come.

Whereas, there has been presented to the Director General of Intellectual Property an application for the grant of a patent for an invention as described, shown and claimed in the documents annexed and attached hereto, and made part hereof,

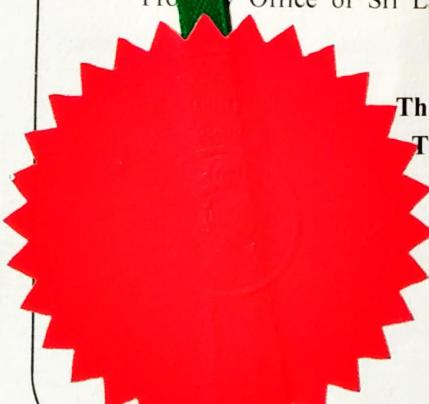
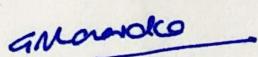
Whereas, the application is in compliance with all the requirements of the Intellectual Property Act No. 36 of 2003 and Regulations made thereunder,

A patent is hereby granted to the person whose name, address and other relevant information are given hereunder and the patentee shall have for a period of twenty years from the filing date of the application for the patent, subject to the provisions of the Intellectual Property Act No. 36 of 2003, the exclusive rights to exploit the patented invention, to assign or transmit the patent and to conclude licence contracts involving the patent.

The patentee who intends to keep the patent in force is required to renew the patent before the expiration of two years from the date of the grant of the patent and each succeeding year during the term of the patent.

In witness whereof I have hereunto caused the seal of the National Intellectual Property Office of Sri Lanka to be affixed in the city of Colombo on this

Thirteenth day of October of the year  
Two Thousand and Twenty Three

  
  
Director General of Intellectual Property

**Patent No :** 21653

**Date of Filing :** 08/03/2021

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**Title of the Invention:** *A wheel that includes autonomous adjustable grousers*

**Priority Data, if any:** --

**International Patent Classification (IPC) :** B 60C 27/10, B 60C 27/04

**Date of the National Search Report :** 03/04/2023

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**International Search Report:**

**No:** --

**Date:** --

**Issued by:** --

## Description

### Title of invention

A wheel that includes autonomous adjustable grousers

### Technical Field

This invention relates to autonomous wheel systems. To be more specific, this invention pertains to wheel systems used on surfaces with dynamic conditions.

### Background Art

- **507 Mechanical Movements**

Design number 224 of an expanding pulley is used

- **US3016270 - Tractor Wheel with Adjustable Grousers**

A cam ring is used to extend or retract the grousers in the tractor wheel to a certain extent by the operator manually. 'A wheel that includes autonomous adjustable grousers' employs an extendable pulley for the extension and retraction of grousers, which are done automatically based on surface parameters.

- **US1696449 - Adjustable Grouser Wheel**

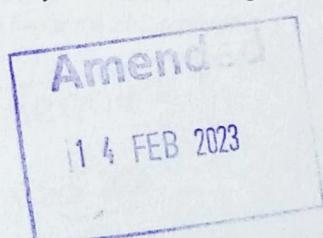
A system of pinions and a sleeve to which the grousers are connected are used to extend or retract the grousers in the tractor wheel to a certain extent by the operator manually with a powered mechanism or by hand while the wheel is stationary. 'A wheel that includes autonomous adjustable grousers' employs an extendable pulley for the extension and retraction of grousers, which are done automatically based on surface parameters while the wheel is moving.

- **RU0002709510 - Quick Release Anti-Skid Device**

A system that makes use of bosses to hold grousers that can be released during a slippage with springs and self-locking nuts to create a one time anti-skid device. 'A wheel that includes autonomous adjustable grousers' employs an extendable pulley for the extension and retraction of grousers, which are done automatically based on surface parameters.

### Technical Problem

Wheels attached to a vehicle or a payload tend to slip and/or sink when traversing on surfaces with certain properties like dust, loose soil and snow. Changes to the weight of the payload, changes of soil parameters of the traversing surface, and changes of inclinations of the traversing plane increases the chance of that happening. This can lead to loss of performance, wastage of power and the failure of missions due to a failure of the wheel system due to sinking



The employment of fixed height grousers have improved the problem in same cases, but can actually contribute to the problem in other cases.

### Technical Solution

A grouser system is implemented where the grouser height is adjustable while the wheel is rotating which changes the effective diameter of the wheel while moving. This allows for the rapid adjustment of wheel to suit any changes in the terrain like surface type and inclination as it occurs as it occurs as it control the changes of sinkage, slippage and rolling resistance and contains the amount of power needed to traverse. Optimizations also allow a wheel to climb steeper inclinations, carry different payload weights and allows traveling in various soil and surface types. There is also the option of integrating different sensors to obtain inputs and build more accurate algorithms for grouser adjustment.

### Brief description of drawings

Figure 1 - front view of the wheel

- 1 - spikes
- 2 - grousers
- 3 - Pushing bar
- 4 - Outer wheel
- 5 - Rim
- 6 - Main axle hole
- 7 - Grouser pins
- 8 - Grouser pin guider gear
- 9 - Small gear

Figure 2 - angled view of the inner parts of the backside of the wheel

- 10 - Motor
- 11 - Power transmitting brushes
- 12 - Pushing bar guider

### Advantageous effects

Rapid adjustment of grousers with surface changes increasing efficiency and accessible area  
Option to integrate sensors and implement autonomous algorithm for adjustment

### Mode for invention

An outer wheel (**4**) is the outermost portion of a wheel that includes autonomous adjustable grousers, and the outer wheel (**4**) encloses all internal components. Five precisely cut holes are carved into the outer wheel (**4**) to guide grousers (**2**) in and out. A rim (**5**) with five spokes, coaxially linked to the outer wheel (**4**) from the inside and to a pushing bar guider (**12**) sharing the same rotational axis as main axle hole (**6**), provides the structural strength to the outer wheel (**4**) and supports the holding of internal components. Each of the five arms of the pushing



bar guider (12) contains a pushing bar (3), which allows it to slide to and from the center of the pushing bar guider (12).

Pushing bars (3) are rigid bars that transmit forces from a grouser pin guider gear (8) to the grousers (2). Each pushing bar (3) is attached to a grouser (2) which is a ring sector with embossed spikes (1) facing out from the outer wheel. Pushing bars (3) allows the adjustments of grouser height by sliding them bi-directionally through the pushing bar guider (12). The adjustable grouser assembly is a combination of a pushing bar (3), grouser (2) and spikes (1).

Each adjustable grouser assembly is connected to a curved slot in the grouser pin guider gear (8) through a small cylindrical extrusion on one-side of the pushing bar guider (12). A grouser pin (7) is fastened to the cylindrical extrusion of a pushing bar guider (3), allowing the grouser pin guider gear (8) to be positioned on top of the pushing bar guider (12). The grouser pins (7), together with cylindrical extrusions of pushing bar guider (12) that are inserted inside the curved slots of the grouser pin guider gear (8), transform rotational motion into linear motion and allow the height of grousers (2) to be adjusted.

A motor (10), a DC-powered high torque servo, is attached to an arm of the pushing bar guider (12), which has an extrusion on the side (Fig. 2) to hold the motor (10). The motor(10) generates the force required to adjust the adjustable grouser assemblies by turning the grouser pin guider gear (8), which translates to a linear motion of the grouser (2) by moving the pushing bars (3) using the grouser pins (7) and curved slots of the grouser pin guider gear (8). The axle of the motor (10) is connected to a small gear (9), which is a spur gear meshing with the grouser pin guider gear (8), via a bearing. When the motor(10) is powered up, the small gear (9) and grouser pin guider gear (8) turn accordingly.

Power transmitting brushes (11) are installed in the center of the back of the pushing bar guider (12), surrounding the main axle hole (6). Wires are routed through power transmitting brushes (11) fastened to the main axle hole (6). These brushes are used to transfer power between two rotating objects: the wheel that includes autonomous adjustable grousers and its host robot or vehicle. The entire system, which includes the adjustable grouser assemblies, grouser pin guider gear (8), grouser pins (7) and pushing bar guider (12) is referred to as an expanding pulley mechanism in the literature.

To use the wheel that includes autonomous adjustable grousers, one needs to insert it into the axle of a robot or a vehicle through the main axle hole (6) and supply power through the axle by running required wires through it, so that the power transmitting brushes (11) are able to transmit power to the motor (10) that controls the expanding pulley. Supplying a current causes the motor to rotate both the small gear (9) and grouser pin guider gear (8) as they are meshed together. The grouser pin guider gear(8) exerts a force on the five grouser pins (7), causing all pushing bars (3) to be pushed towards the outer edge of the wheel. As a result, the grousers (2) are raised, increasing the traction between the wheel and the terrain. In contrast, flipping the direction of the current causes the grousers (2) to contract. This process is initiated by inverting all previous steps. The grouser pin guider gear (8) exerts an opposing force on each of the

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grouser pins (7) while drawing the pushing bars (3) inwards as the motor (10) now turns in the opposite direction. As a result, the height of each grouser (2) is reduced by a similar amount while the traction is adjusted to the desired level. Once the grousers (2) have been extended or contracted to a specific height, a constant torque can be delivered through the motor (10) to maintain them in place by supplying a constant current. Grouser pin guider gear (8) evenly distributes forces and torques along all the grouser pins (7) to ensure the smooth functionality of the wheel system in any circumstance.

In addition, as adjustable grousers increase the effective diameter of the wheel, they can be used to control the changes of sinkage, slippage and rolling resistance based on terrain parameters. An external sensor and CPU are required to execute modifications based on terrain parameters. A LIDAR sensor could be used in the host robot or vehicle to determine the sinkage of its wheels as it moves along the terrain. This data could then be processed by an external processor, and the appropriate adjustments of the grousers (2) could be recognized based on the requirements of the user. A power signal based on the required adjustment could then be transmitted to the wheel that includes autonomous adjustable grousers to change its grouser (2) height.

Though the present invention was shown and described with references to the preferred embodiment, such is merely illustrative of the present invention and is not to be construed as a limitation thereof, and various modifications to the present invention will be apparent to those skilled in the art. It is, therefore, not intended that the present invention be limited to the disclosed embodiment or details thereof, and the present invention includes all variations and/or alternative embodiment within the spirit and scope of the present invention as defined by the appended claims.

### Industrial Applicability

Can be used in robotic rovers / vehicles with rigid wheels

Can be further developed for use in automobiles, snow vehicles and amphibious vehicles as the use of grousers would help movement in these surfaces and environments.

This technology allows a robot or vehicle to climb steeper inclinations and allow traveling in various soil and surface types, and also work efficiently with a range of different payload weights. In addition, as this method reduces the uneven stresses and strains acting on a wheel, wheels tend to have a longer working time, making them suitable for applications like space rovers and remote area vehicles.



## Claims

1. A wheel that includes autonomous adjustable grousers comprising:

adjustable grouser assemblies that are individually consisting of a grouser (2) with spikes (1) and connected to a pushing bar (3) that can slide towards and away from the center of a pushing bar guider (12);

an expanding pulley consisting of five adjustable grouser assemblies that are attached to a grouser pin guider gear (8) via grouser pins (7) which are individually connected to a small cylindrical extrusion on pushing bars (3) and that can slide within the curved slots of grouser pin guider gear (8) to enable bi-directional movement of adjustable grouser assemblies to adjust grouser heights;

a gear system consisting of a grouser pin guider gear (8), which is connected to the pushing bar guider(12) and meshed with a small gear (9) directly attached to the axle of a motor (10);

a motor (10) that is powered by wires running via power transmitting brushes (11) and is attached to a main axle hole (6) of a rim (5) that is aligned with the grouser pin guider gear (8);

an outer wheel (4) that encloses all the internal components and is internally connected to the rim (5) that connects with the pushing bar guider(12) and rotates along the main axle hole (6).
2. The wheel that includes autonomous adjustable grousers in claim 1, wherein the height of grousers (2) is adjusted using the expanding pulley that includes adjustable grouser assemblies that are attached to a grouser pin guider gear (8) through grouser pins (7) which are individually connected to a small cylindrical extrusion on pushing bars (3) and that can slide within the curved slots of grouser pin guider gear (8) to enable bi-directional movement of adjustable grouser assemblies.
3. The wheel that includes autonomous adjustable grousers in claim 1, wherein the height of grousers (2) is dynamically adjusted while the wheel is rotating.
4. The wheel that includes autonomous adjustable grousers in claim 1, wherein power transmitting brushes (11) are attached to the wheel axle to provide power to an internal component of the wheel, the motor (10).



## Abstract

This paper presents an invention of an autonomous wheel system that consists of adjustable grousers to maintain stability in a large range of surfaces. The adjustable grousers vary the amount of the grouser that is extended from the surface of the wheel to change the effective diameter of the wheel and control the values of sinkage, slippage and rolling resistance of the wheels. This happens rapidly with changes of the surface and while the wheel is moving making sure of maximum efficiency and stability. The grousers are expanded and contracted using the rotation of an expanding pulley, which push or pull the grousers using pins from the grouser that travel along rails in the pulley. The current for the motor of the expanding pulley is provided using brushes on the axle. Sensors and an external IC with an autonomous algorithm can be integrated with the system which will continuously monitor surface changes and adjust the grouser height so that the rover will maintain stability efficiency in surfaces outside which it is optimized for.

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# Drawings

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Figure 01

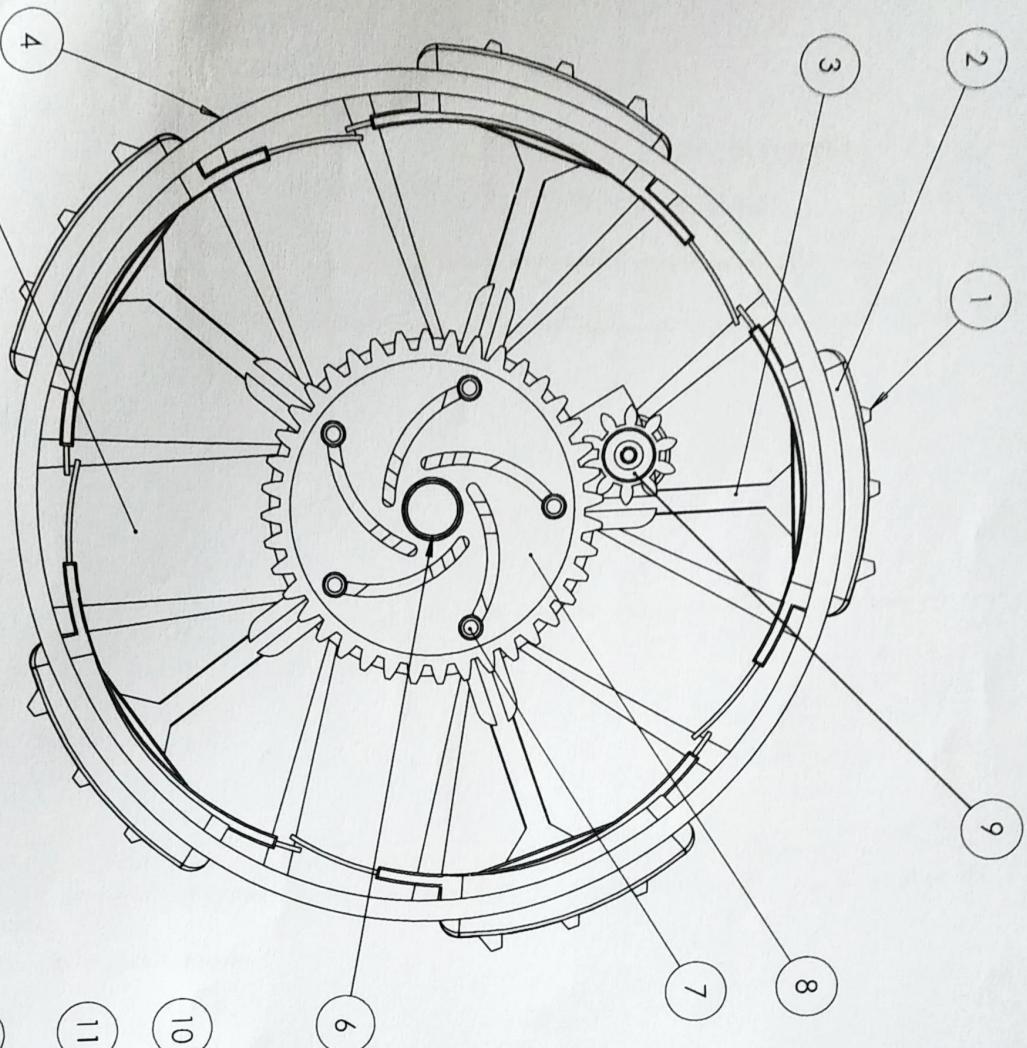
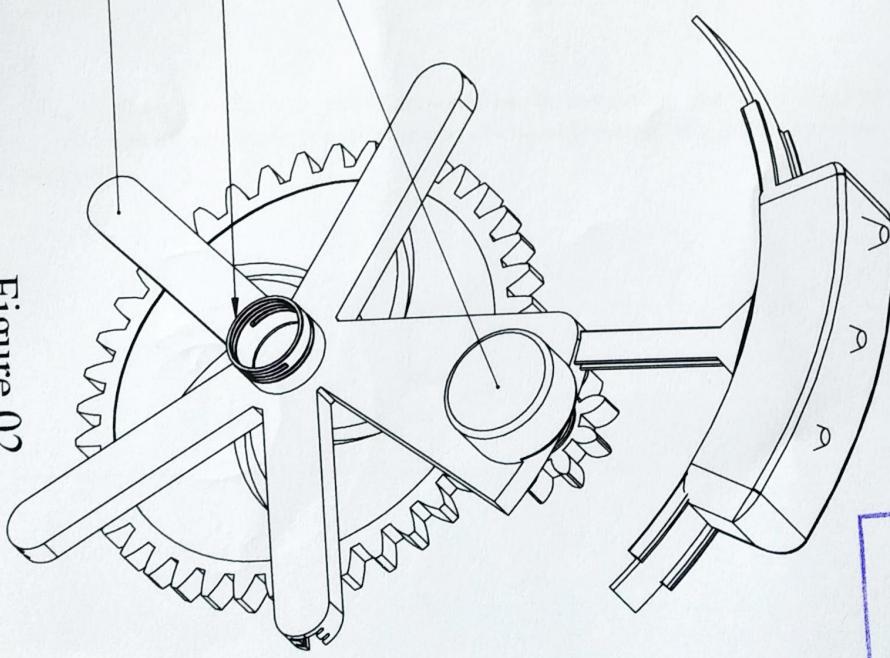


Figure 02



**INTELLECTUAL PROPERTY ACT NO. 36 OF 2003**  
**SEARCH REPORT ON APPLICATION NO: 21653**

**Title : A wheel that includes autonomous adjustable grousers**

- 1. Does the application relate to an invention within the meaning of Section 62 of the Act? Yes**  
(If not, please give reasons)
- 2. Does the title indicate the invention? Yes**  
If not , please suggest an alternative title:
- 3. Does the description disclose the invention in a manner sufficiently clear and complete for the invention to be evaluated and to be carried out by a person having ordinary skill in the art? Yes**  
If not, please give reasons:
- 4. (i) Does the Claim or the Claims define the invention clearly and properly? Yes**  
If not ,please state the number (s) of the objectionable Claim(s) and give reasons for objection(s):

(ii) Is/are the Claim(s) fairly based on the disclosure? Yes  
If not, please elaborate:

5. (i) Is the Invention new having regard to the prior art searched? Yes  
If not, please give the number(s) or other details necessary to identify the prior publication(s) or prior art:

(ii) Number(s) of claims(s) anticipated by prior art, if any,:  
\_\_\_\_\_

6. Related art:-  
\_\_\_\_\_

7. Other comments, if any:  
Search report issued on amendment dated 14/02/2023

8. Field(s) searched, (e.g. C07C) : B 60C  
\_\_\_\_\_

9. Abstract(s) to be placed in file(s): Int.Cl.  
B 60C 27/10, B 60C 27/04  


Examiner's name / signature:- NKAAbhayarunwa

Date:- 3 April 2023



**ශ්‍රී ලංකාවේ ජාතික තුළදීමය දේපල කාර්යාලය**  
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**NATIONAL INTELLECTUAL PROPERTY OFFICE OF SRI LANKA**

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 3rd Floor, 'Samagam Madura', No. 400, D.R. Wijewardena Mawatha, Colombo 10, Sri Lanka.

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Your No. }

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Date } 19 /10/2023

1. Mr Viduranga Shenal Landers  
No. 281/7/H, Samagi Mawatha, Kerawalapitiya,  
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No. 239, Dalupitiya, Kadawatha.
4. Mr M. R. R. Jude Thidushan Peiris  
5/1, Bogahawatta Road, Hekitta, Wattala.

Dear Sir,

**A wheel that includes autonomous adjustable grousers**  
**Patent Application No: 21653**

The above titled patent has been granted to you on 13/10/2023, and the certificate is annexed hereto.

2. We wish to inform you that the Ministry of Education and specifically the following institutions functioning under the said Ministry have the mandate to support inventors/ patent holders to commercialize their inventions. Therefore, you may contact them for further information, in order to obtain the support of the government to commercialize your patent protected invention.

(i) Additional Secretary (Development & Innovation),  
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 Tele: 011 2186290

(ii) Chief Innovation Officer,  
 National Innovation Agency,  
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(iii) Sri Lanka Inventors Commission  
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(iv) National Science Foundation,  
 47/5, Vidya Mawatha, Colombo 07.  
 Tele: 011 2694170, 011 2696771-3

Yours faithfully,

*Geethanjali R. Ranawaka*

Geethanjali R. Ranawaka  
 Director General of Intellectual Property

- Copy:
- i) Additional Secretary (Development & Innovation), Ministry of Education- for information and follow up to support the patent holders.
  - ii) Chief Innovation Officer, National Innovation Agency - To provide further assistance.
  - iii) Director, Sri Lanka Inventors Commission – To provide further assistance.
  - iv) Director General, National Science Foundation - To provide further assistance.