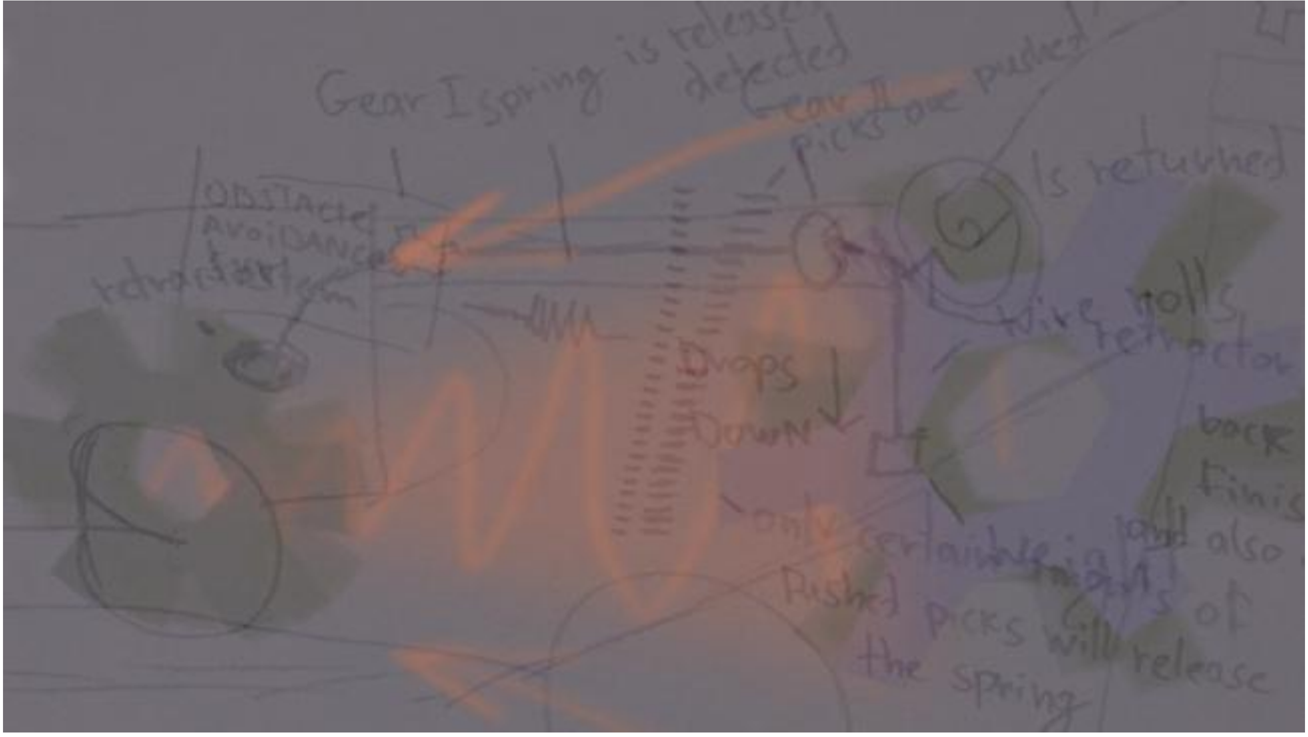
Title

Lockpicking Obstacles



Short description

The sensor acts similar to a lockpicking mechanical device. Sensor picks the obstacles based on the number of rotations of the gear within.

Please describe, in a non-confidential way, the operation of your sensor.

Sensor Design

As shown in *Diagram I* the sensor extends in front of the rover and has a weight that will drop under the force of gravity to hit the ground and be sent back afterwards. As the wire is pulled further, the gear will rotate and register every full rotation. During a rotation, one of the gears shifts out until a full circle is executed and drops back to the initial position afterwards [*Diagram II*]. A full revolution pushes one of the picks. Certain amounts of revolutions will signal that there is an obstacle. If an obstacle is picked, this will result in the spring retaining the force to further direct the rover in the away direction *[Diagram V*]. The weight at the sensor's periphery will be pulled back upon the impact with the ground, which will signal end of operation. The mechanical retractor would come in contact with the picking mechanism to push the picks. This will be the decisive action that will either unlock the obstacle, or will just be a failed attempt, which means it's fine to drive forward.

Sensor Structure

Sensor's main parts are:

- 2 gear structures
- a structure that supports the gears - for example, elongated pipes in front up to 1m
- a wire that goes through the gears
- weight that is fixed at the utmost periphery
- a mechanism inside the rover similar of a mechanical retractor's that functions similarly to those found in vacuum cleaners
- lockpicking mechanism beside the retractor. It will trigger the release of the force string which will drive it back in case the obstacle can be confirmed.

Sensor Mechanics

The successful execution of obstacle detection will mainly depend on the gear's rotation, the end of operation signal, interaction of the retractor with the lockpicking mechanism, and the performance of the lockpicking mechanism.

- The gear

Generally a gear structure is not mandatory for the initial design, but the idea behind it might be useful if the sensor would need to count the rotations on a higher granularity, which would be counting partial rotations. As seen in *Diagram III* one of the ways to bring back the gear to its initial position is to automatically release the central part that is being rotated upon the nut on the end of a rotation.

- End Of Operation

The end of operation would be triggered by a weight of about 10-15kg that on obstacle encounter would drop and will be immediately pulled back afterwards.

- Retractor

The retractor will release the weight when the obstacle will be encountered and will pull it back as soon the extension will end. The stop of the fall would signal to lock the mechanism and pull the cable back.

- Lockpicking Mechanism

To decipher the obstacle, the lockpicking mechanism "picks" the lock inside the rover. From the weight, to the gears and back to retractor, everything is a chain reaction that interacts step by step with the picking mechanism to rule out of there is an obstacle. Please see on the mechanics of the mechanism in section *how will the sensor trigger the pins*.

Considerations

Errors and power adaptations are as possible, as different variations of the design itself. Please see *Diagram VI* for some possible modifications with the idea of reliability improvement.

A couple of issues worth mentioning is the main gear and the action of dropping weight for spotting the obstacle. The gear might additionally need a supporting mechanism that would ensure that it might not lag during the rotations. Dropping weight might as well not work as expected due to winds and pressure. However, to ensure that the sensor can reach the ground more alterations can be considered and a couple of thoughts are shown in *Diagram VI*.

Please provide a schematic diagram of your proposed sensor.

sensor diagrams.pdf

Please indicate the performance criteria your sensor can achieve:

Detect slopes greater than 30 degrees (up or down)
Detect rocks greater than 0.35m in height
Detect holes deeper than 0.35m

Please describe how your sensor is suitable for the operational environment on Venus. Consider describing how your sensor design will cope with high temperatures, high atmospheric pressure, wind, launch vibrations, etc while in operation

The sensor is based on mechanical performance, which allows to choose any suitable durable materials for its construction. It can contain titanium, platinum, gold and any material that would do well on Venus environment. As the sensor requires a lot of metal, titanium might be a perfect choice for most of its parts.

The wire can be designed to have a diameter of 3-5 cm, which allows the appliance of more layers of insulation to protect it from the environmental heat. Other careful considerations have to be made on the gear itself as its stability is crucial in a successful obstacle detection.

The external parts of the sensor can be sealed quite well to avoid inconsistencies during rover's movement. While encountering an obstacle, the greatest external problem might pose the pressure and wind which could lead to a disbalanced weight fall. If the weight cannot fall reliably, a mechanism that would push it or further alternations might be considered. Other parts of the rover should cope well with the environment as besides, there is nothing specific to overprotect.

Please describe the materials you anticipate needing for constructing the sensor.

For durability and stability it would be required for the sensor to consist mostly of metal parts, such as titanium.

Platinum, Nichrome and Karma can be used within the wire for strengthening. These materials also show a good conductivity and environmental resistance, which might be useful in case the obstacle could be detected more reliably with electric signals. (See more in *Sensors A Comprehensive Survey Edited by N Gopel, J. Hesse, J. N. Zemel Mechanical Sensors Volume 7*)

Please describe the electrical power requirements of your sensor. Describe what electrical components are included in your sensor and why. If none, please indicate "Not applicable".

Not applicable

Please describe how your proposed sensor will trigger the pin(s).

The concept is based on registering the torque of the sensor's extension. The sensor extends and judging by the number of executed torques it mechanically evaluates whether there is an obstacle or not.

During the obstacle detection the weight drops creating an trapezoid figure between the rover on obstacle. See *Diagram IV* for schemes of the possible obstacles and follow each of [Calc[X]] where the schemes sync with the calculations below:

[Calc I]: Pythagoras theorem is used to find the length of hypotenuse within the triangle in the trapezoid:

$$0.875^2 + 1^2 = 1.76$$

$$\sqrt{(1.76)} = 1.33\text{m}$$

[Calc II]: The angles within the triangle are calculated which will be needed to further identify the distance between the sensor and obstacle. Since the smallest angle has 30 and lowest 90, we can consider these angles to have the same ratio 1:3. Which we will be:

$$90/4 = 22.5° \text{ (the smaller angle)}$$

$$22.5*3 = 67.5° \text{ (the greater angle)}$$

[Calc III]: Since we know the angles we can now find the other ones within the triangle:

$$90° - 67.5° = 22.5°$$

$$30° - 22.5° = 7.5°$$

[Calc IV]: Since we have the fixed lengths, we can use for example the Sinus law to find the length we need and prove as well that the calculations fit well by verifying if our anterior known angle outputs 150:

$$180.00^\circ - 7.50^\circ - 22.50^\circ = 150^\circ$$

$$(\sin(7.50^\circ)*1.33\text{m})/\sin(150^\circ)= 0.35\text{m}$$

$$(\sin(22.80^\circ)*1.33\text{m})/\sin(150^\circ) = 1.02\text{m}$$

0.35 is the result that we are looking for. This is used to identify how many rotations will signal that there is a 30 degree slope that goes up (see **Picking Mechanism**).

To identify holes equal or greater than 0.35m it is needed to add up the length of the hole depth and the distance of the sensor from the sensor which is:

[Calc V]:

$$0.35\text{m} + 0.875\text{m} = 1.225\text{m}$$

For rocks higher than 0.35 can be applied the same method:

[Calc VI]:

$$0.875\text{m} - 0.35\text{m} = 0.525\text{m}$$

To see the how far the weight has to drop to identify the distance between the sensor and obstacle on a 30° down-slide, can be used a similar method as in the first calculations, where the slope went up 30°:

[Calc VII]: The ration between the unknown angles is 1:1.666, and below the result is based on rounding and approximation to further find the length:

$$150^\circ / 2.7 = 56^\circ\text{(greater angle)}$$

$$180^\circ - 56^\circ - 90^\circ = 34^\circ\text{(smaller angle)}$$

[Calc VIII]: Finding out the angles from the triangle we are interested in:

$$90^\circ - 34^\circ = 56^\circ$$

$$150^\circ - 56^\circ = 94^\circ$$

[Calc IX]: Using the same logic as previously where the slope went up to find the needed length:

$$(\sin(94^\circ)*1.33\text{m})/\sin(56^\circ)= 1.6\text{m}$$

$$(\sin(30^\circ)*1.33\text{m})/\sin(56^\circ) = 0.8\text{m}$$

The distance between the sensor and obstacle is 1.6m.

Picking Mechanism

The picking mechanism picks the locks based on the number of rotations executed. To identify the obstacles, the circumference of the gear is considered and in the current design it is 0.05πm (0.157m). With the calculations above can be found out the following:

- Initial distance to the ground where the lock won't be picked: 0.875m / 0.157m = 5 rotations
- 30° slope up: 0.35m / 0.157m = 2 rotations
- 30° slope down: 1.6m / 0.157m = 10 rotations
- rock 0.35m high: 0.525m / 0.157m = 3 rotations
- hole 0.35m depth: 1.225m / 0.157m = 7 rotations

Since now it is known how to measure some of the obstacles, the lockpicking mechanism can be set up accordingly. For example, 5-6 rotations might be considered no threat, and the rover would drive forward, and all others then would signal danger. Depending on different of other predictable obstacles, the mechanism can be adjusted to react to certain number of rotations accordingly.

Considerations

Although the sensor can confirm if there is an obstacle or not, it cannot predict if there will be a hole or a slope before encountering it. Predicting the approaching obstacle would be a side functionality and could rely on differentiating the force in the wheels, detecting a jump in velocity change with an accelerometer or as well a mechanism that stops the rover every [x] time or [x] distance and checks for obstacles.

Please describe how your sensor meets the physical constraints of the current rover design (i.e. assembled of environmentally appropriate materials, mass ≤ 25kg, not more than 1m from rover body, not more than 0.875m off the surface)

The main exterior parts of the sensor rely on 2 metallic gear-like structures with an approximate radius of 5-10 cm and a construction that can hold them in place. Depending on the construction of the pipes that would hold the torques, it gets into to the realm of quite flexible design which creates a conceptual possibility to adjust to such limits.

The detection of obstacles would be most effective with the pipes elevated as high as possible, and considering a 0.875m off the surface and 1m off the body is enough to create an angle which would detect them. The examples proposed in this design take these measurements, however, the sensor could still be reduced in length and be placed somewhat below if that would be more reliable. Considering the weight limit as well, it would still be possible to create a durable and functional sensor with the correct materials.

Please indicate the current maturity level of your sensor: Conceptual