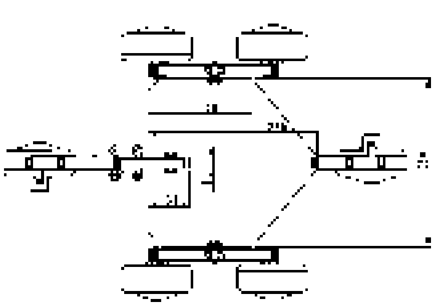
RESEARCH & DEVELOPMENT

Mobile intelligence "off-road"

STANDARD MOTORS KEEP VEHICLES MOVING ON TOUGH TERRAIN

Modern computer and sensor technology is perfect for fast, reliable data-gathering. Even such inhospitable environments as volcanoes, furnaces and the inner workings of nuclear power stations are no longer a problem. Unfortunately, this technology has always had one disadvantage: its lack of mobility. Until now, investigations of unknown territory have been hampered by the lack of a universal vehicle concept for carrying instrumentation. Areas which are inaccessible to humans nearly always demand vehicles that are extremely manoeuvrable and capable of dealing with difficult terrain. Just a few examples: investigations of mining accidents, searches in inaccessible construction sites, mine detection or even – far surpassing all of these demands – the exploration of other planets. All of these applications call for a high degree of reliability, redundancy and autonomy – all features of the new "Shrimp" vehicle concept.



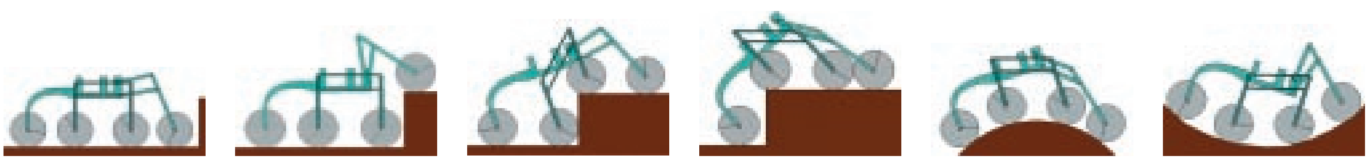
Of course, there are plenty of concepts and designs for "all-terrain" vehicles. Look a bit closer at all the design options, however, and it soon becomes apparent that they are all based on just a few practicable solutions. First, there are the tracked, or "crawler" vehicles, which rely on a simple but well-established technology. Then there are the so-called "walking" machines, which have been improved by modern control technology to achieve better results. Last but not least, the most widely used solution, the wheeled vehicles. Each of these solutions has its advantages and disadvantages.

Take tracked vehicles as an example: they are easy to steer, they operate well on difficult terrain and can be turned in a very confined space – but they require a comparatively high drive power. They are also relatively heavy and there is a large amount of wear on the chassis. To operate at all, travelling machines require complex, active positional control and, for the foreseeable future at least, are bound to be quite slow. In fact, they are hardly much faster on level surfaces than on rough terrain. Wheeled vehicles are also easy to steer and manoeuvrable. Moreover, they are light and therefore require little drive power. On rough terrain, they are capable of surmounting larger obstacles, but can also drive at a higher speed on a flat surface.

It was for these reasons that the ASL (Autonomous Systems Lab) of the École Poly-technique Fédérale de Lousanne (EPFL) decided in favour of the wheeled

FAULHABER standard motors with an integral encoder supply the drive power

option for its new vehicle concept. Previous solutions in this field had the drawback of being designed for use on either rough terrain or level surfaces. The difference with the new "Shrimp Rover" is that it is a universal vehicle designed for both applications.



The concept

The vehicle is essentially based on an all-wheel drive concept. This is the only way of consistently ensuring an optimum drive power to the wheels with best-possible traction. A positive "side-effect" of a single-wheel drive system is the redundancy of the drive motors.

Sophisticated chassis kinematics were developed to optimise the contact between the ground and all of the wheels. An all-terrain concept is based primarily on ground clearance – after all, why "climb" over something if you can "roll" over it. This is why two different wheel suspension systems have been provided on the vehicle body.

A special parallel architecture has been used for the side wheels. This keeps the virtual centre of rotation of the four-wheeled intermediate chassis at an optimum point between the wheel axles. The chassis itself, on the other hand, is positioned high above the wheel axle. In order to gain optimum advantage from the resultant ground clearance, even in surmounting obstacles, the vehicle has also been provided with a front and rear wheel. Special lever kinematics are also employed to ensure that the front wheel is always optimally guided on the traction surface, while the rear wheel is fixed to the main body of the vehicle via an outrigger arm.

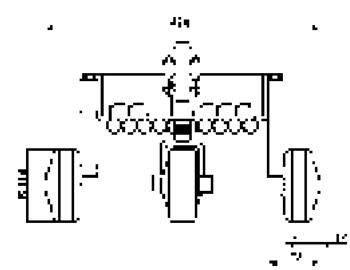
In purely mechanical terms, the special design of the vehicle, with a front and rear wheel and 2x2 side wheels, means that the ground contact of all the wheels is optimised, so that active control is not necessary. Due to the swivelling capability of the front and rear wheels, the turning circle of the Shrimp is also very small, in the range of the vehicle length.

Despite this manoeuvrability, however, the Shrimp still exploits the main advantage offered by wheeled vehicles: the drive friction is extremely low, so that virtually all the output drive power is available for propulsion. There is therefore no problem in using energy-saving drives with a back-up battery system.

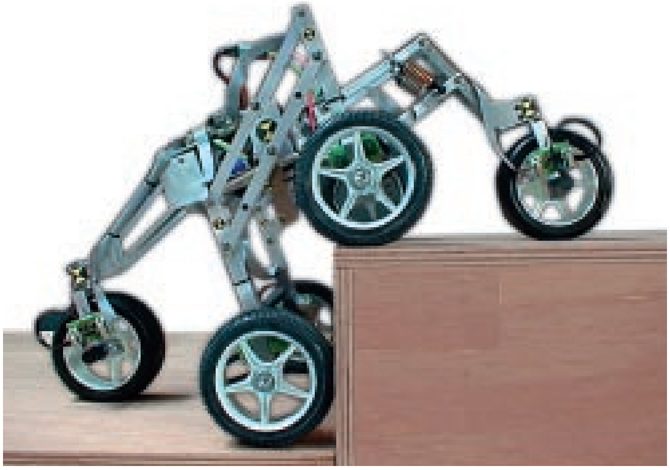
Drive solution

Designed as a universal vehicle, it was important for the Shrimp to have a drive system capable of dealing with every possible application. The system chosen was a motor concept from the FAULHABER product range. The company's motor and transmission range is structured in such a way that constructors can virtually select components to put together their own modular drive systems. For the Shrimp, the constructors used the 2224...SR series DC micromotors with precious-metal commutation. The ironless bell-armature motors are available in different voltage variants. They deliver 4.2 W and can be started with even the lowest voltages – an extremely important feature for planetary exploration trips relying on a solar cell power supply or battery operation with voltages that drop at lower temperature.

Yet another advantage of the chosen motor design is the integral magnetic pulse generator. Depending on the



One vehicle for all conditions, whether irregular terrain, steps or slopes.



Ingenious chassis kinematics – all the wheels follow the relief of the terrain.

model, 64 to 512 pulses are generated for each revolution, and evaluated by the motor control unit. Gears are then needed to match the torque characteristic to the wheel geometry. The motors are combined with planetary gears which, with reduction ratios of 3.71:1 to 1526:1 and a torque of 0.5 Nm, provide a large bandwidth for optimum drive adaptation. Since each wheel reports its drive data to the control system via its own phase sequence indicator, the entire drive of the vehicle can always be regulated optimally according to the traction and slip data from the individual wheels. An electronic differential lock is just as feasible as assistance for turning on the spot. Since all the drive components are from a standard range, the price advantage over conventional special-purpose drives is enormous.

Expandable

The sophisticated concept of the "Shrimp Rover" enables it to climb over steps up to a height of double the wheel diameter. This climbing ability outstrips all current concepts by far. The vehicle has a high level of stability over difficult terrain, mastering front/side inclination up to 40°.

A low-cost version is largely comprised of symmetrically designed individual components. With this model the payload can also be picked up at the front or rear. The concept is particularly suited for applications where the emphasis is on high profitability or where losses can be expected. The main fields of application could therefore be agriculture, minesweeping robots, and exploration robots for industry. The new vehicle concept from EPFL is based on an ingenious, purely mechanical, rugged chassis. It is driven using low-cost standard parts from the FAULHABER Group and controlled with conventional components.

Nevertheless, boasting superior reliability, it is suitable both for sophisticated space travel applications and for earth-bound applications. Its high level of efficiency in forward motion and its exceptional climbing ability when encountering obstacles are the perfect solution for universal application on any terrain.

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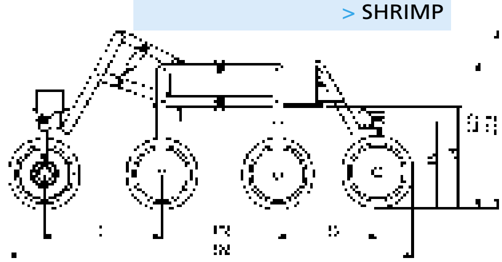
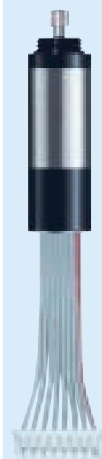
www.bluebotics.com
> SHRIMP



8 mm

INNOVATIONS

Motion is OK … controlled motion is better!



M 1:1

New pulse encoders in series 05A and 05B for DC micromotors

The new micro-pulse encoders with a diameter of only 8 mm are suitable for combination with FAULHABER DC miniature motor sizes 8 mm, 10 mm and 12 mm. They are simply and ruggedly designed and do not contain any sensitive coding disks, LEDs, or phototransistors. Vibrations, temperature fluctuations, dust and incidence of light cannot harm them. The housing effectively prevents electromagnetic radiation from being emitted.

With a magnetic disk, two signals are achieved which are in phase quadrature. Sensors fed from a stabilized-voltage power supply and an integrated circuit generate an analog/digital output signal. On the low-cost Type 05A, 1 analog signal per revolution generates 2 sinusoidal output signals and 2 complementary signals. Type 05AB even achieves 1 analog signal and 8 digital signals per revolution, i.e. 2 sinusoidal signals and 2 square-wave, TTL/CMOS-compatible output signals. The operating temperature range is between –25 °C and +85 °C.

When delivered to the customer the pulse encoders are already preassembled on DC micromotors. The combination has been tested and is ready for operation – simply plug in and let it run. A selection of precision gearheads with high torque supplements this compact motor-pulse encoder combination and makes it a powerful drive system for a very wide range of applications in motion control engineering.

weblinks

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