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The Actuator: Demining Innovations

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Features

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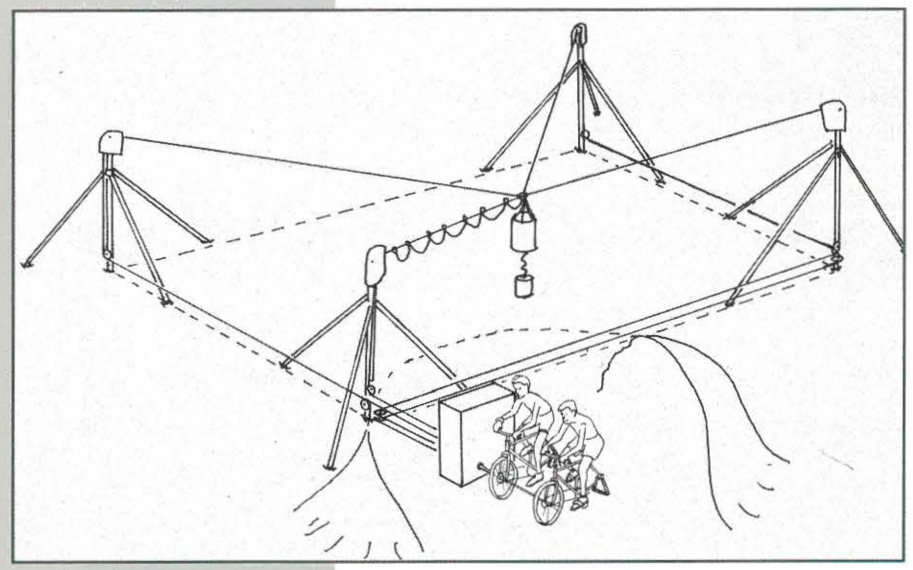

Sketch of a conceptual 4-pole system driven by power from two stationary bicycles. Straight broken lines indicate the extent of the parcel of land to be probed. The actuator is suspended at the juncture of four cables extending from the corner poles. Pulleys conduct these cables to the rectangular housing containing the electromechanical parts, including the clutches operated by the microprocessor. Power is transmitted to the actuator through a wire suspended from the near pole along its cable. A protective earthen berm (curved solid and broken lines) is shown cut away to expose the elements at the near pole.

Graphic c/o L. Felsenstein, T. Wright, E. Brechin. Caption c/o Felsenstein and Saunders

by Lee Felsenstein and Steven E. Saunders, Ph.D.

This approach to humanitarian demining differs from generally accepted methodology. It has not yet been tried, and the purpose of this article is to ensure that the general concept is placed in the public domain, where it may be debated and modified without considerations of intellectual property. Interval Research Corporation, where this idea originated, is not in the business of mine clearance, or of manufacturing mine clearance systems, so the idea is being passed along to the community best capable of analyzing it.

Mines are built to destroy themselves when triggered by an external event. If we can simulate the triggering event adequately, we can clear an area of mines by detonating them on site. For anti-personnel mines this means simulating the tread of humans to the necessary degree of impact and repetition. During this process the system used must not be seriously damaged by the detonation of mines, and operating personnel must be kept safe.

In accordance with John Walker's concept of "Moore's Law in the Minefield," http://www.fourmilab.to/minerats, our system is intended for local manufacture and assembly using one or more high-technology components produced in high volume at low cost. Our concept differs from Walker's semi-autonomous "mine-rat" robots in that ours is a stationary system erected on a parcel of land able to probe the entire surface of the parcel to an arbitrary degree of fineness.

Military doctrine opposes on-site detonation. Attempts at clearance by flails and similar devices have proven unreliable and likely to render unexploded mines hypersensitive. It is our observation that those devices are relatively expensive and are typically applied to the task for a short time under control of skilled personnel. We propose instead a system that works over a much longer period of time under control of local personnel using local energy sources.

The system we envision would consist of three or four well-braced upright poles holding pulleys on a plane above the mined ground. Positioning-cables feeding over these pulleys would join at a central point, where the "actuator" would be suspended. This actuator serves the function of probing using a weight to simulate the human triggering effect.

Positioning systems such as this have been used for positioning cameras over large open areas (www.august-design.com/html/projects/prj_skycam.htm) and the use of such a system in a demining application is described by Havlik and Licko (See vol. 2.2 of The Journal of Mine Action http://www.hdic.jmu.edu/hdic/journal/2.2/features/havlik.htm).

Several different methods of actuation are possible. One might be a bundle of chain mail raised and dropped repeatedly. Another might consist of a water-filled bag made of cheap plastic drawn or rolled across the surface. We claim no expertise in actuator design and recognize that optimum actuator design will not be determined without extensive testing. Power to operate the actuator would most efficiently be transmitted mechanically by additional pulleys run from the poles.

The fundamental principle of operation is that the control module knows the position of the actuator on the horizontal plane at all times, probably through electronic sensing of cable extensions as processed through simple trigonometry. The control module would contain dedicated microprocessor controllers operating on input signals from sensors located on the suspension poles. The poles then control the electrical actuation of clutches, which apply prime motive power to the positioning cables.

The 'closed loop' is formed by the path from cable extension sensors through the microprocessor and its software, to the clutches and to the extension of the positioning cables. Reference monuments would be necessary to allow the system to recalibrate itself, given the inevitable shifting of the poles. The software controlling operation would be built into a protected control module in the form of read-only memories (ROMs). The control module would be built to move the actuator successively over every element of the surface below it, and to remember the last point at which the actuator probed. The operators would have a few commands; start, resume, recalibrate, and stop. The operators may choose to run the system through as many complete passes over the mined land as they desire.

Prime motive power for the system need not be electrical. A shaft would be provided which may be turned by whatever power source is available. The operation of the shaft would generate sufficient electrical power to operate the control module and its clutches, in addition to mechanically performing the shift, drop and lift functions of the actuator. Persons involved in the operation on site must, of course, be protected from the fragments generated by mine detonations by beams or similar obstacles.

This system is intended to take advantage of economies of scale and the low cost of local labor. It should be distributed by a multi-tiered system involving training of local personnel in the process of installation and maintenance, and in the training of on-site operators. Control modules and other high-tech components would be contracted for and distributed by organizations having an interest in promoting mine clearance at low cost. Lower-technology items would best be manufactured locally, and tools and training may constitute the imported items in this case.

The manufacture of the control modules would best done either by one concern (thus maximizing the volume of units over which to amortize expenses) or by a number of smaller concerns building to a standardized design, thus allowing for price competition (although quality would have to be monitored rigorously). The design of such a system, capable of being built from varied locally sourced materials and operated by minimally trained personnel, will not be a simple task. Achieving the necessary reliability of operation from the controller components will require the application of software design techniques perfected in the automotive industry.

It may be appreciated why no benefit would accrue from patenting or otherwise protecting the general system design, since assembly of the system would take place far from any mechanisms for enforcing such ownership. The systems should, we believe, be paid for and owned by the local people or community whose land is being cleared, so that the effects of proprietorship will be manifest. The "sale" of the system components (which will be partially subsidized) should, we believe, include an agreement to resell at controlled prices, perhaps through the agency handling distribution and training in the local country. In this way the allocation of the components goes first to the locality that can raise the initial price, which is then refunded (less depreciation) by the next purchaser and so forth until the components wear out. This would, we hope, be a long time, given that each user sees the components as valuable property to be protected from depreciation and sold off as soon as its local use is complete.

Some might object that we are postulating a billiard-table environment whereas the real world is much more complicated. We acknowledge, of course, that paths will have to be cleared manually to allow the erection of this system on mined land. It is less difficult to demine manually a linear path than a whole field. The presence of brush overgrowing the mine field is an obstacle that can be addressed by fitting brush-clearing attachments to the actuator so as to allow for safe removal. Manual control of the actuator movement may be necessary for this phase.

We also acknowledge that our proposed system will not clear mines in all terrain and circumstances. But we believe that it can be greatly useful in clearing mines in a large number of locations, thus freeing human resources to clear mines in more difficult areas.

Demining is tedious, life-threatening work, which requires that every bit of the field be swept or probed. What better task to pass to a machine, given that computers are only good at tedious, repetitious actions? And why not let the mines blow themselves up if only the machine will feel the blast (and be easily and cheaply repairable)? To the design philosophy now stylish in Silicon Valley, expressed by the phrase "fast, cheap and out of control," we counterpose a different ethos of "slow, cheaper and highly repetitious," which will better serve those who live with anti-personnel mines in their ground. ■