Lessons Learned from Terrestrial Telerobotics

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KISS workshop Space Science Opportunities Augmented by Exploration Telepresence

October 3, 2016

The nature of presence.

How it has evolved?

Presence is measured by the extent you could use your senses, mobility, and dexterity to interact with the environment.

Presence used to be defined as "boots on the ground".



That has changed, most importantly for places where it is hard to be.

Electronically mediated "presence" has flourished, in the last fifty years, because of our growing competence.

"Telepresence"



"telegarden" c.1990



Put into practice in the cold war by nuclear assembly practicioners

But commercial terrestrial use of telepresence now goes vastly beyond this.



Offering vision, hearing, and even mobility!

So electronically mediated "presence" is a fact of life.



But it's dexterity as well, for telepresence!

Telerobotic surgery





Telerobotic mining

So how does telepresence fit into the context of **space exploration**?





Robert Heinlein anticipated this back in 1946, with *Waldo*.

Of course, we've established expertise Putting our vision, mobility, and some dexterity on Mars!

But there's a problem ... "exploration" doesn't really look that way, does it?









Our cultural mandate for "exploration" is **still** "boots-on-the-ground".



Maybe rovers should be designed like this, to put "boots on the ground"!





"Boots" on the Earth

Exploration is the act of putting human presence at an interesting site. It is no longer just the act of putting human boots at that site.

Who's the "explorer" here?

"Boots" (or wheels) on Mars



But electronically putting all human senses and capabilities at a site for telepresence is hard

- vision
- hearing
- smell
- touch
- dexterity
- mobility

compared to view through helmet

to the extent it's important ...

not possible in EVA suit

compared to EVA gloves

compared to EVA gloves

compared to EVA suits

What's even harder, for space exploration with telepresence, is TIME DELAY (latency).

One issue we're confronting at this workshop is how latency effects planetary science performed with telepresence.

Can't do anything about the speed of light (or radio waves).

2-way latency

no prob! HRT~0.2 sec Around the Earth ~0.15 seconds Earth-to-Moon ~2.6 seconds inconvenient ... Earth-to-Mars 8-60 minutes OUCH!

How would control latency affect a task? Driving a car? Playing soccer? Putting away groceries?

Simple things can accommodate latency. Hard things can't. Latency drives task time.



Space Telerobotics in the Dark Ages: The Telepresence Adventure of Lunokhods



The Soviet Union successfully sent telepresence-controlled rovers to the Moon in 1970 and 1973.

They were driven in "real-time" by drivers on Earth. But 20 second latency!

VERY HARD!





Of course, Curiosity isn't operated in "real-time" on Mars. Command uploads happen once a day. VERY low quality telepresence.

In principle, we can design robots that transmit human-quality vision, hearing, dexterity, touch, mobility.

But we can't do much about latency. If we're controlling them from the Earth.

But what if we're not?!

What if we're controlling it from NEAR the planet? Like in orbit overhead? LOTS closer than the Earth!



"Low-Latency Telepresence", or "Exploration Telepresence"

That's what this workshop is all about. *Understand* opportunities and challenges of Low-Latency Telepresence for planetary exploration.

+ Astronauts stay safely in orbit overhead.

Landing is hard, and dangerous! Fighting gravity can hurt. Planetary surface may not be amenable to human life. Venus?

- + Can control robotic surrogates all over the planet. Presence in many places.
- + Investigations can take place over long periods of time. Don't run out of air.
- Most of your science smarts are back on Earth. Latency gives time to think!
- Maybe humans in situ can do stuff that humans can't do telerobotically In situ astronauts make for ZERO latency. Stuff breaks.
- Contact may be only periodic depending on orbit.





How does one DO field geology, without having boots-on-the-ground?

Maybe low-latency telepresence.



How might our new capabilities for achieving human presence make for evolution of exploration?

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