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NeuroRex: I Think … Therefore … I Walk

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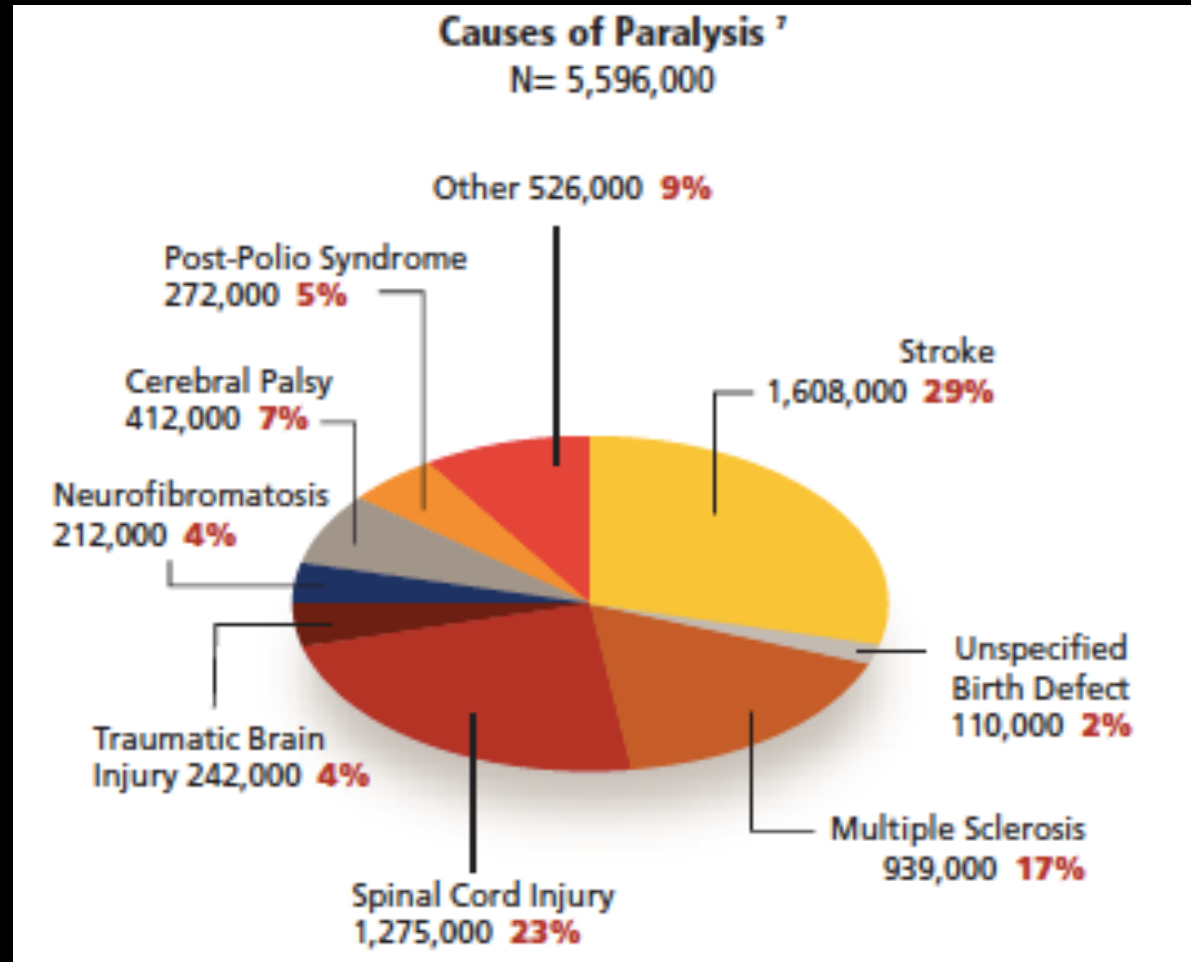University of Houston

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Laboratory for Non-invasive Brain-Machine Interface Systems

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REX BIONICS

Causes of Paralysis [7]
N= 5,596,000

Other 526,000 **9%**

Post-Polio Syndrome
272,000 **5%**

Cerebral Palsy
412,000 **7%**

Neurofibromatosis
212,000 **4%**

Stroke
1,608,000 **29%**

Unspecified
Birth Defect
110,000 **2%**

Traumatic Brain
Injury 242,000 **4%**

Multiple Sclerosis
939,000 **17%**

Spinal Cord Injury
1,275,000 **23%**

'From One Degree of Separation'
Christopher & Dana Reeve Foundation

Paralysis leads to multiple secondary disabilities

- Spasticity

- Hip, knee & ankle contractures

- Heterotopic ossification of lower extremity joints

- Frequent urinary tract infection

- Reduced heart and circulatory function

- Pressure sores

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Socioeconomic burden of SCI is high

Severity of Injury	Average yearly Expenses (2008 dollars)		Estimated Lifetime Costs by Age at Injury	
	First Year	Each subsequent year	**25 years old**	50 years old
High tetraplegia (C1-C4)	$801K	$144K	**$3.160M**	$1.86M
Low tetraplegia (C5-C8)	$517K	$59K	**$1.787M**	$1.132M
Paraplegia	$293K	$30K	**$1.056M**	$0.72M
Incomplete motor function at any level	$236K	$17K	**$0.704M**	$0.51M

Sources: 2009 Spinal Cord Injury Facts

OUR VISION

Develop intelligent robotics that will:

1. **Innovate and accelerate rehabilitation**

2. **Increase function (quality of life & well-being)**
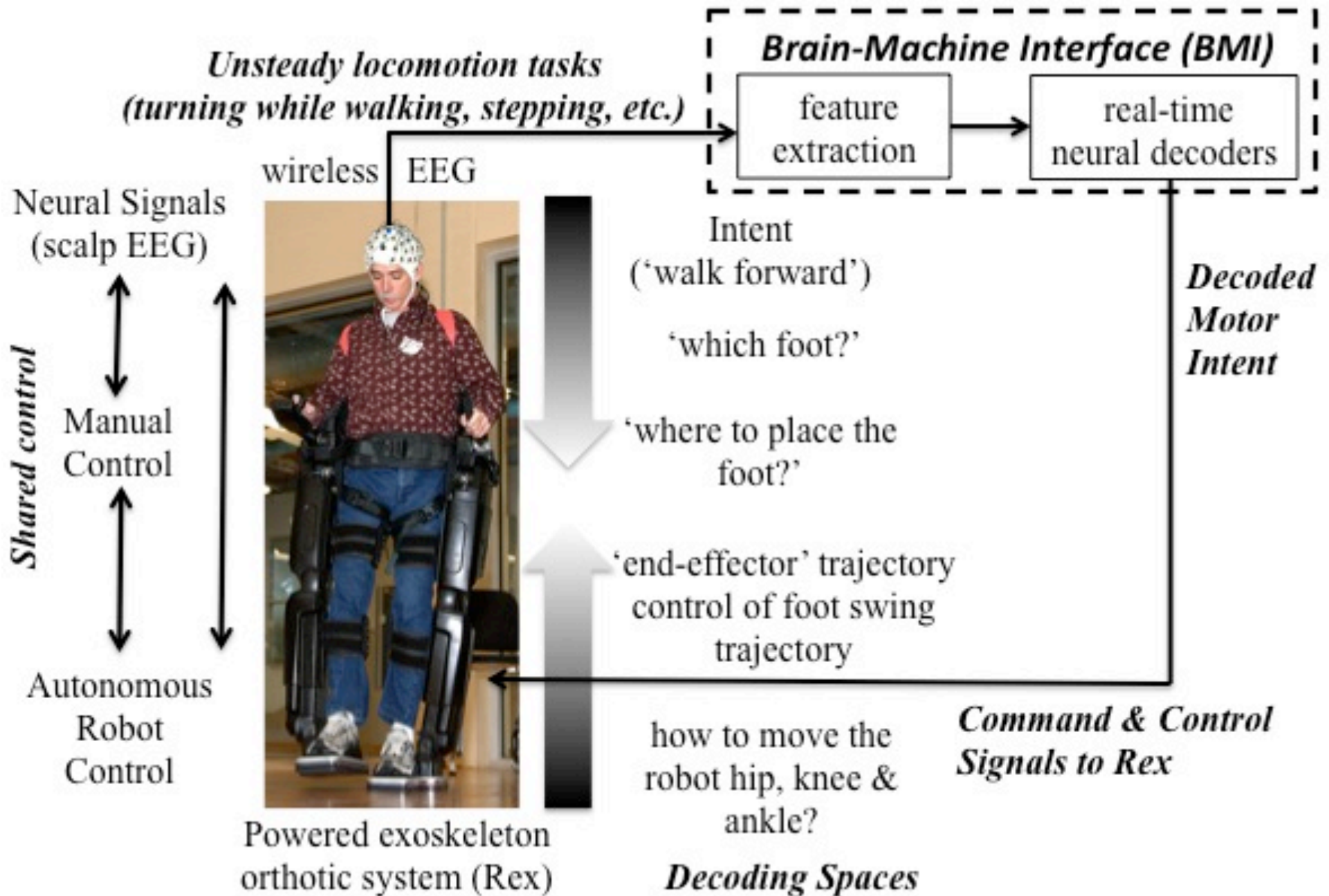
3. **Reverse-engineer the brain**

REX is a sophisticated, precision orthosis yet it is very simple to use and **allows users to walk and work** independently without crutches or walkers.

Goals:

- Bringing **REX** to those who cannot use their hands (tetraplegic) + patients who can be rehabilitated.

- Understanding how the body and the brain adapts to the co-robot (safety and efficacy).

REX
BIONICS

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Brain-Machine Interface (BMI)

Unsteady locomotion tasks (turning while walking, stepping, etc.)

feature extraction → real-time neural decoders

wireless EEG

Neural Signals (scalp EEG)

Intent ('walk forward')

'which foot?'

'where to place the foot?'

Decoded Motor Intent

Shared control

Manual Control

'end-effector' trajectory control of foot swing trajectory

Autonomous Robot Control

how to move the robot hip, knee & ankle?

Command & Control Signals to Rex

Powered exoskeleton orthotic system (Rex)

Decoding Spaces

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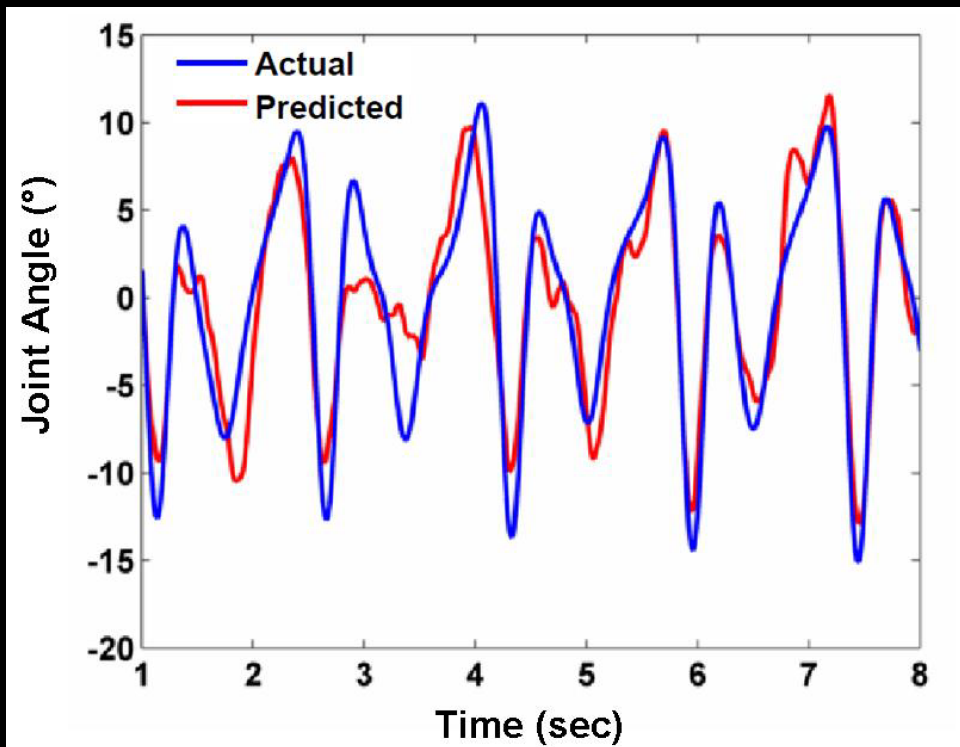
Extracting user's intent from scalp EEG

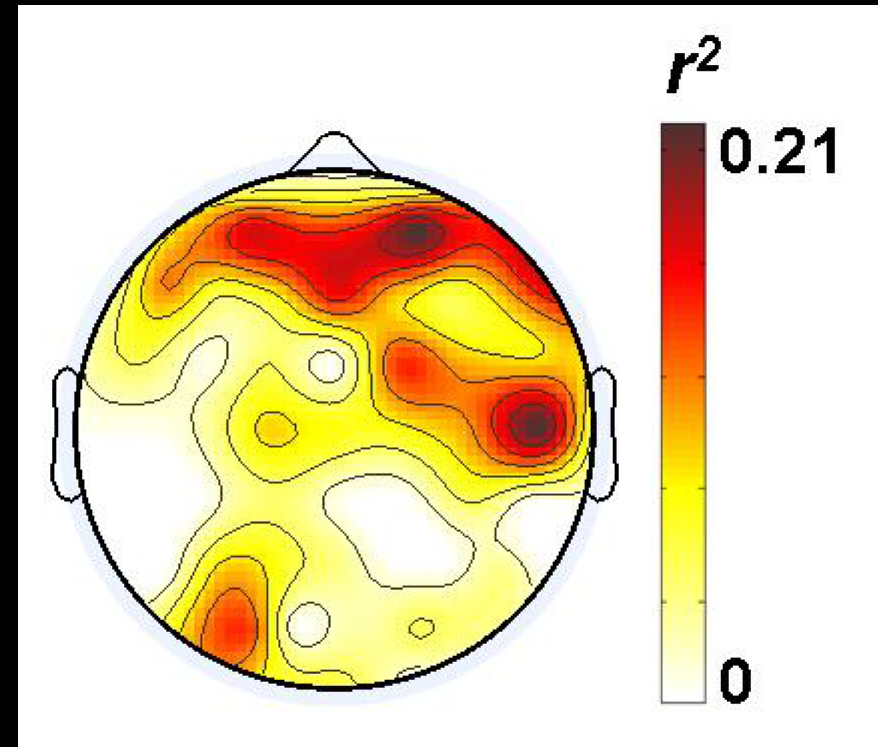Presacco & Contreras-Vidal; J. Neurophys (2011); IEEE TNSRE (2012)

Harnessing the visuomotor representation of movement

Prediction of leg kinematics from scalp EEG

Spatial distribution of gait information (r^2) in sensor space

Enables study of brain plasticity as individuals with incomplete or complete SCI or stroke use the BMI with robotics to learn to walk.

Health Systems Engineering

With our partners at the Methodist Hospital led by Dr. Robert Grossman we will assess **system-wide health benefits of NeuroREX** use after SCI:

- Brain function
- Cardiovascular health
- Bladder function
- Respiratory function
- Bone density
- Well-being

REX
BIONICS

Methodist The Methodist Hospital Research Institute

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