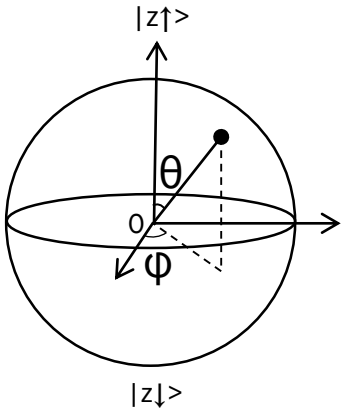
Implementation of Artificial Ego
based on the extended Riemann sphere

The University of Tokyo / SoftBank Robotics Corp.
Collaborative Researcher
TOMONAGA Kosuke, Ph.D.

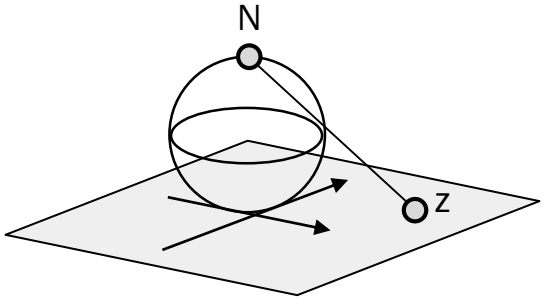
The University of Tokyo
Project Associate Professor
MITSUYOSHI Shunji, Ph.D.

Existing qubit representation

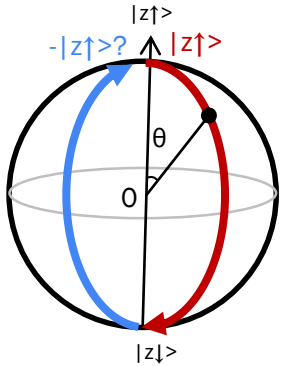
Bloch sphere



Riemann sphere



Bloch sphere and Möbius strip



the Bloch sphere

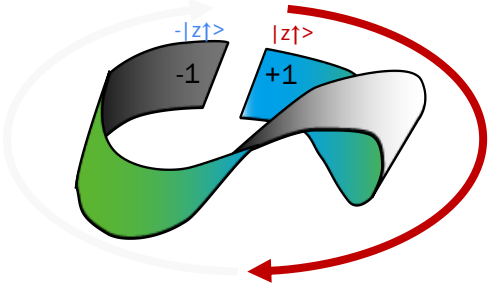
Range of θ

$$|\psi> = e^{i\delta}\left(\cos\theta'\,|z\uparrow> + e^{i\phi'}\sin\theta'\,|z\downarrow>\right)$$
$$= e^{i\delta}\left(\cos\frac{\theta}{2}\,|z\uparrow> + e^{i\phi}\sin\frac{\theta}{2}\,|z\downarrow>\right)$$

$\mathbf{0 \le \theta \le \pi}$, $0 \le \phi \le 2\pi$

A violation of θ causes a contradiction on the diagram.

$$|\psi> = e^{i\delta}\left(\cos 2\pi\frac{1}{2}\,|z\uparrow> + e^{i\phi}\sin 2\pi\frac{1}{2}\,|z\downarrow>\right)$$
$$= e^{i\delta}\left(\cos\pi\,|z\uparrow> + e^{i\phi}\sin\pi\,|z\downarrow>\right)$$
$$= e^{i\delta}\left(-1|z\uparrow> + e^{i\phi}0\,|z\downarrow>\right)$$
$$= e^{i\delta}(-1|z\uparrow>)$$

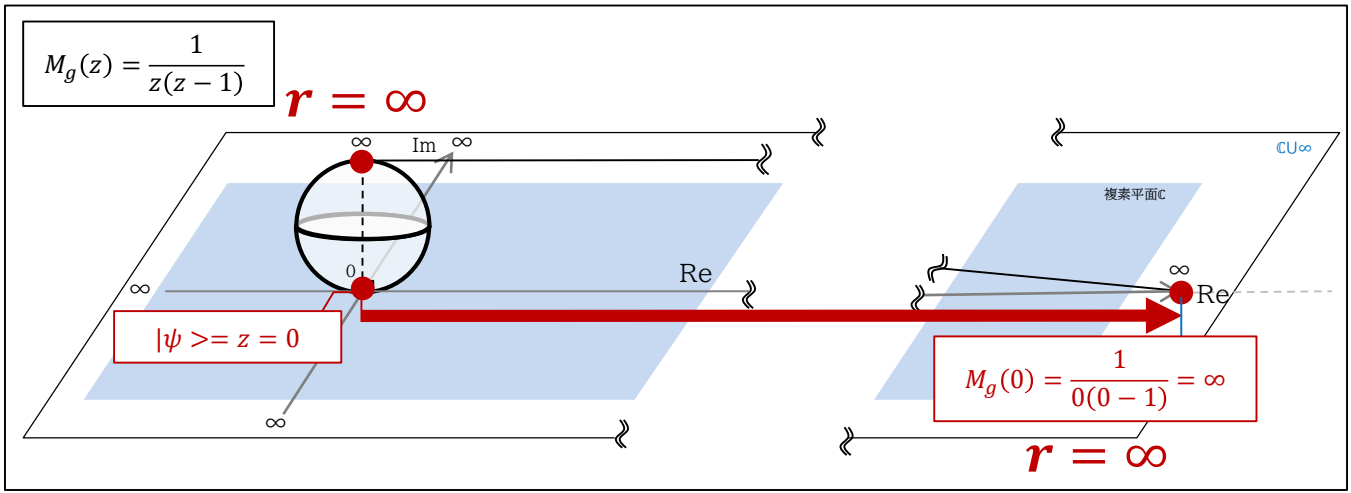


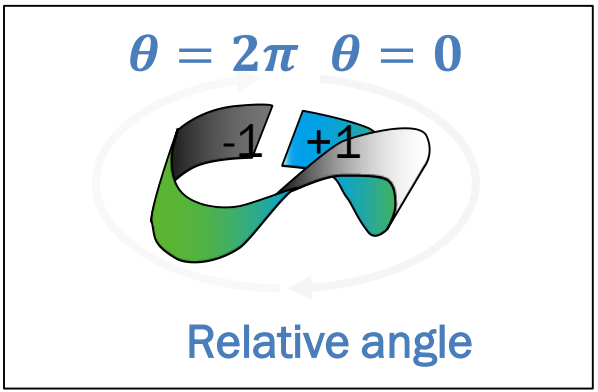
Möbius strip

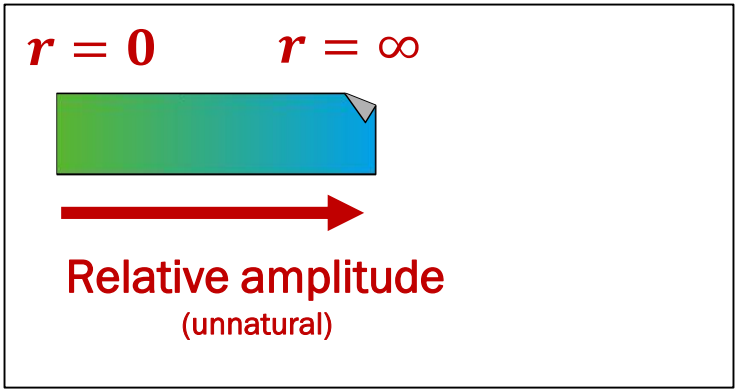
The quantum state correctly reverses after one rotation.

The Mobius strip is natural.

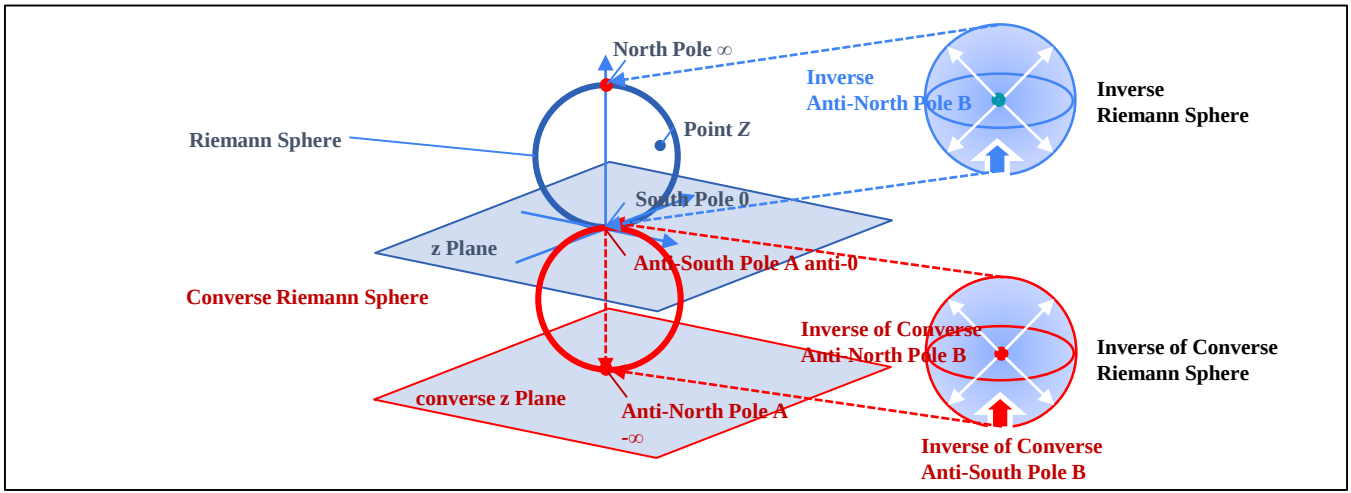
Tautology about infinity



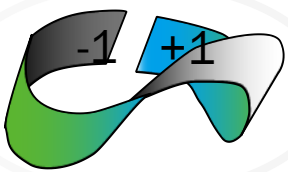




The extended Riemann sphere

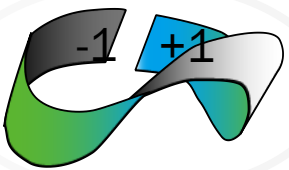


$\theta = 2\pi \quad \theta = 0$



Relative angle

$r = 0 \qquad r = \infty$



Relative amplitude

Our implementation to handle infinities

x-axis

open interval $(-1, 1)$

$$h(x) = \frac{|x|^2}{1 - |x|^2}$$

open interval $(-\infty, \infty)$

$$y = M_g(h(x))$$

Sufficiently large numbers are treated as pseudo-infinities and pure infinities are skipped automatically.

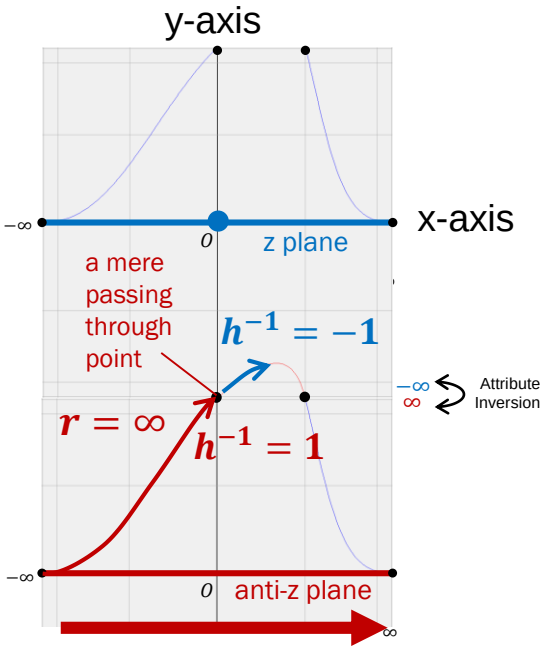
y-axis

open interval $(-\infty, \infty)$

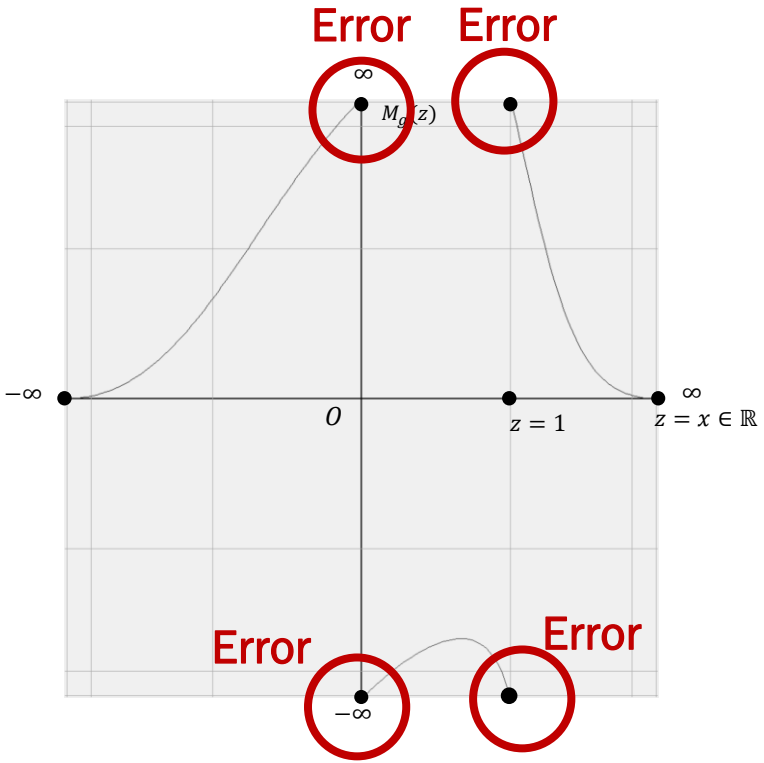
$$h^{-1}(y) = \frac{|y|^2}{1 + |y|^2}$$

open interval $(-1, 1)$

Our implementation

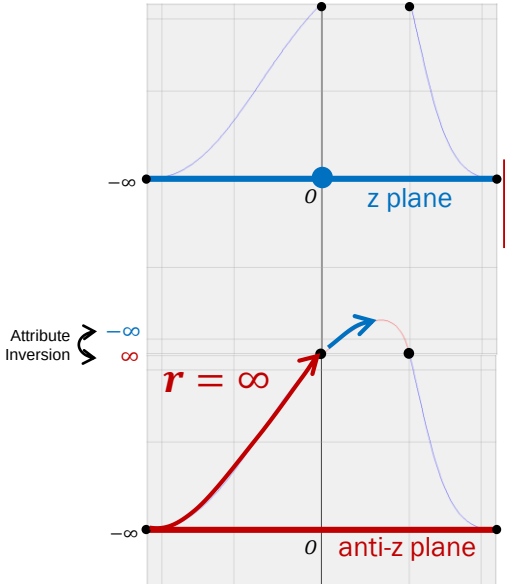


Normal way to avoid infinities

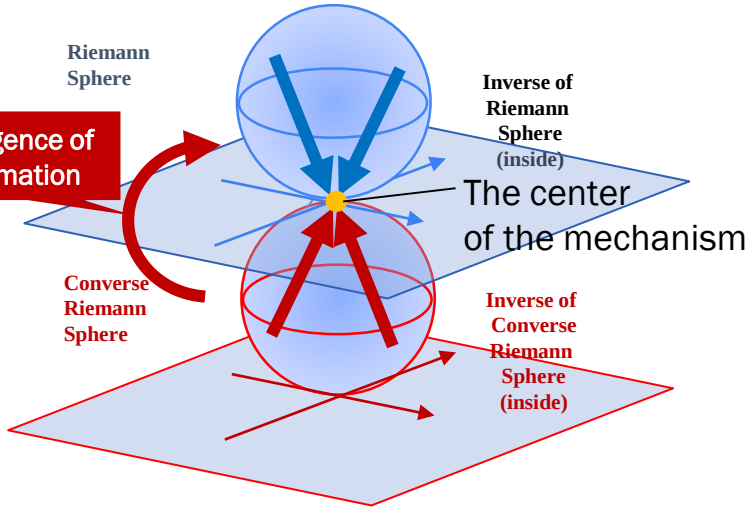


Just remove infinites using if statements

The extended Riemann sphere and Control Engineering



Emergence of information



This mechanism drive the artificial egos.

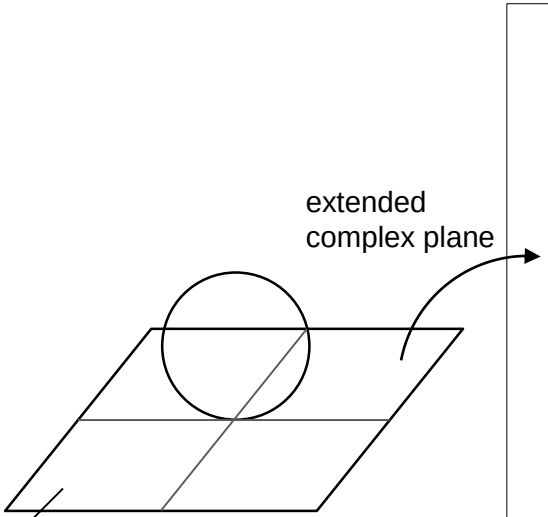
$$G(z) = \frac{1}{z(z-2)}$$

Transfer function of Laplace transform

A correction for our previous presentation (SC2021)

Almost all transfer function are not Mobius transformation even If we could expand the transfer fucntions into partial fractions. Correctly, we are treating the transfer function as the input and output of a Möbius transform.

The extended Riemann sphere and Control Engineering



extended
complex plane

z transform

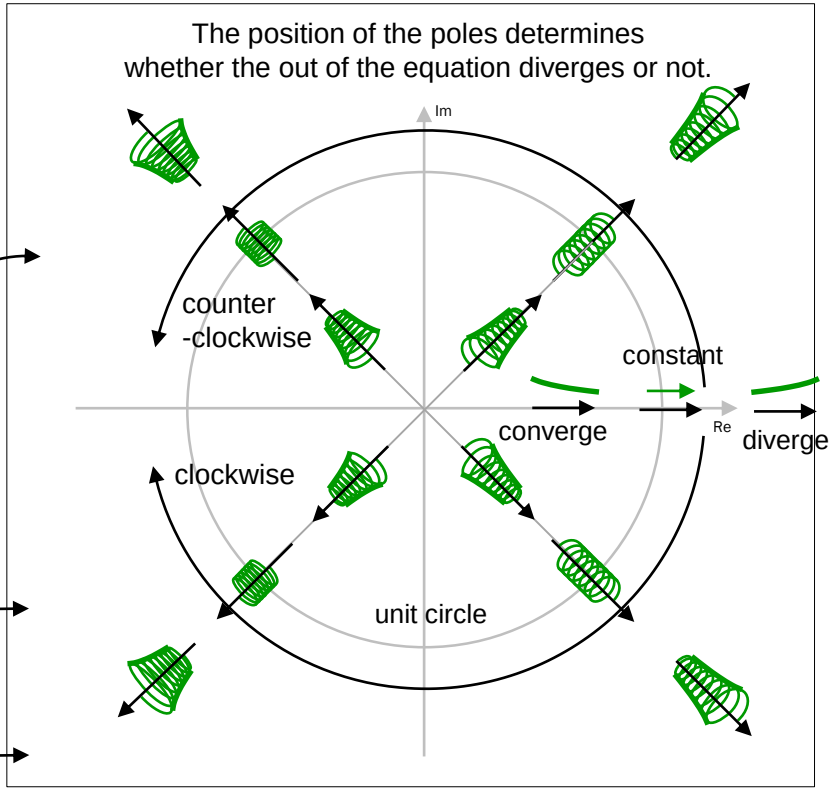
$$X(z) = \mathcal{Z}[x(t)] = \sum_{n=-\infty}^{\infty} x_n z^{-n}$$

z

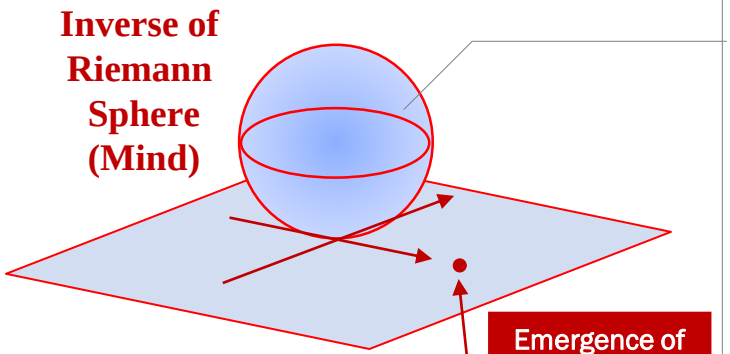
Laplace transform

$$X(s) = \mathfrak{L}(x(t)) = \int_0^{\infty} x(t) e^{-st} dt$$

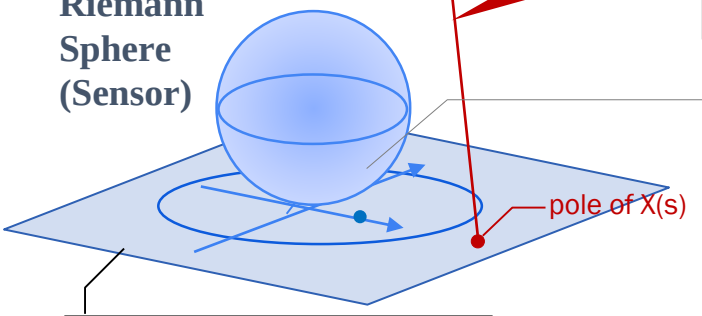
e^{st}



Machine perception, consciousness and desire



Emergence of information



$$X(z) = \mathcal{Z}[x(n)] = \sum_{n=-\infty}^{\infty} x_n z^{-n}$$

Machine consciousness

e.g.

$$\frac{1}{X(z)} = \frac{z-2}{z}$$

Desire

Will of control

reciprocal of each other

e.g.

$$x(n) = \begin{cases} 2^n & (n \geq 0) \\ 0 & (n < 0) \end{cases}$$

$$\Rightarrow X(z) = \frac{z}{z-2}$$

Perception

Things that have risen to consciousness (query for convergence)

Sensor and Motor

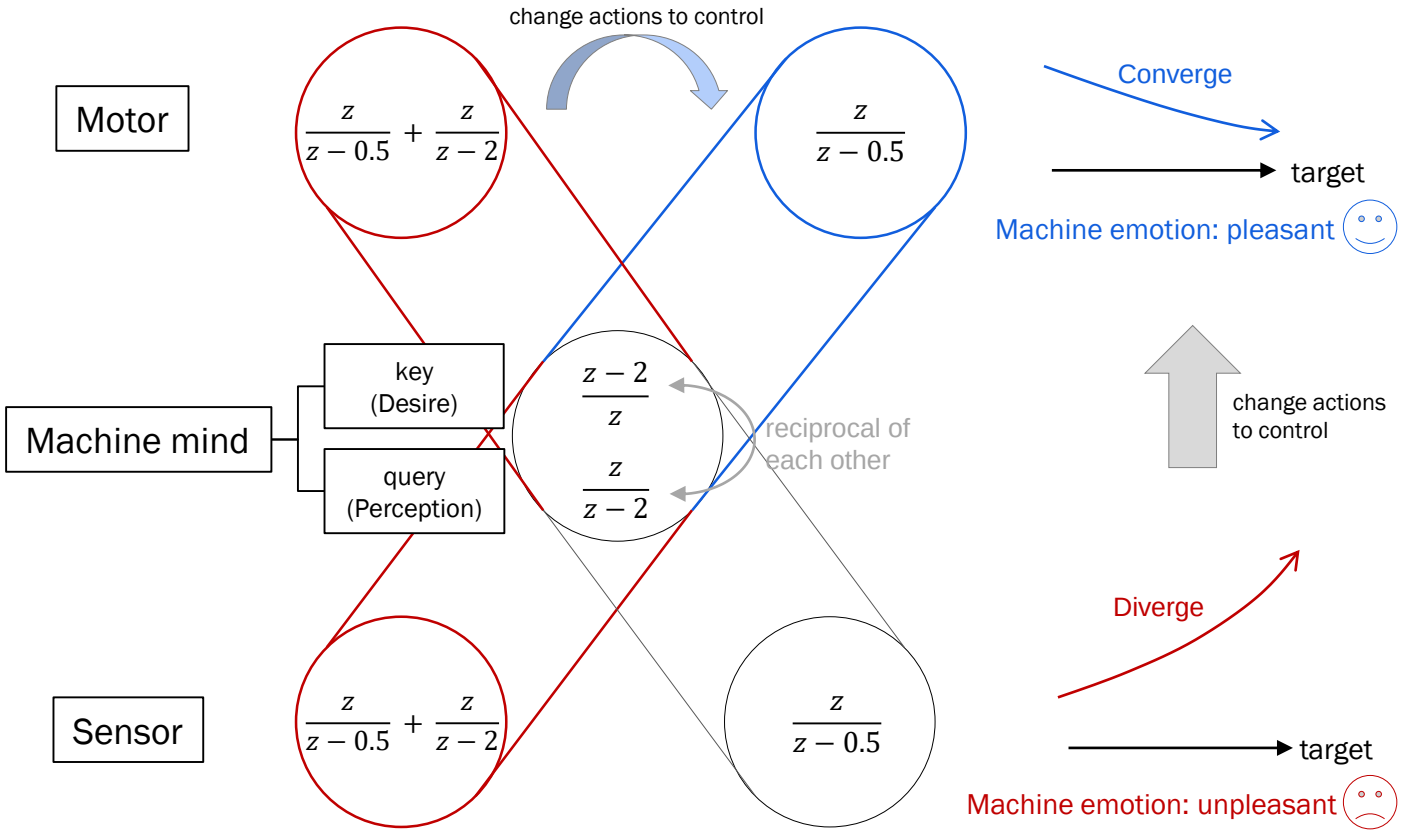
Emergence of information

e.g.

$$x(n) = \begin{cases} 0.5^n + 2^n & (n \geq 0) \\ 0 & (n < 0) \end{cases}$$

$$\Rightarrow X(z) = \frac{z}{z-0.5} + \frac{z}{z-2}$$

Response of machine



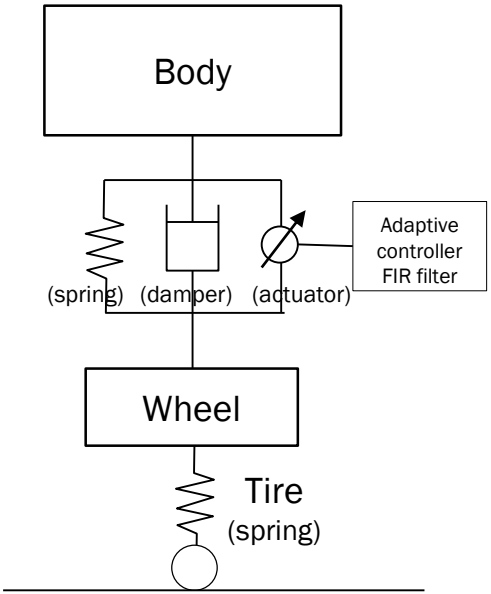
Experiment of Artificial ego

Our experiment is currently underway in Super Formula Next 50 to install an artificial ego in a vehicle for entertainment purposes.

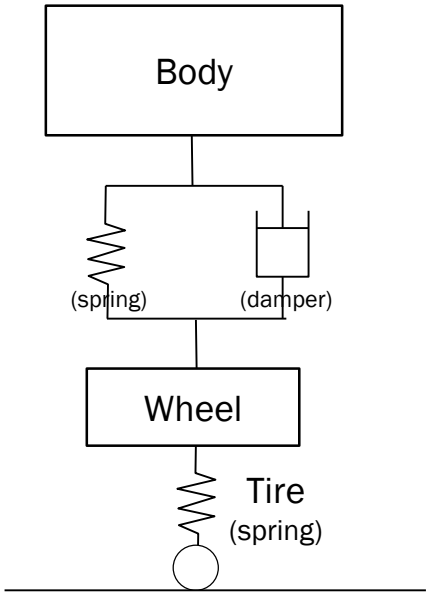
Actually, it is not at the stage of autonomous operation of a vehicle. It will just show its emotion for entertainment.

But, if an artificial ego can operate a vehicle autonomously, what happens? And It is against regulations to install active suspension in the Super Formula, but if it were to be installed, how would AE use it?

Active suspension and normal suspension

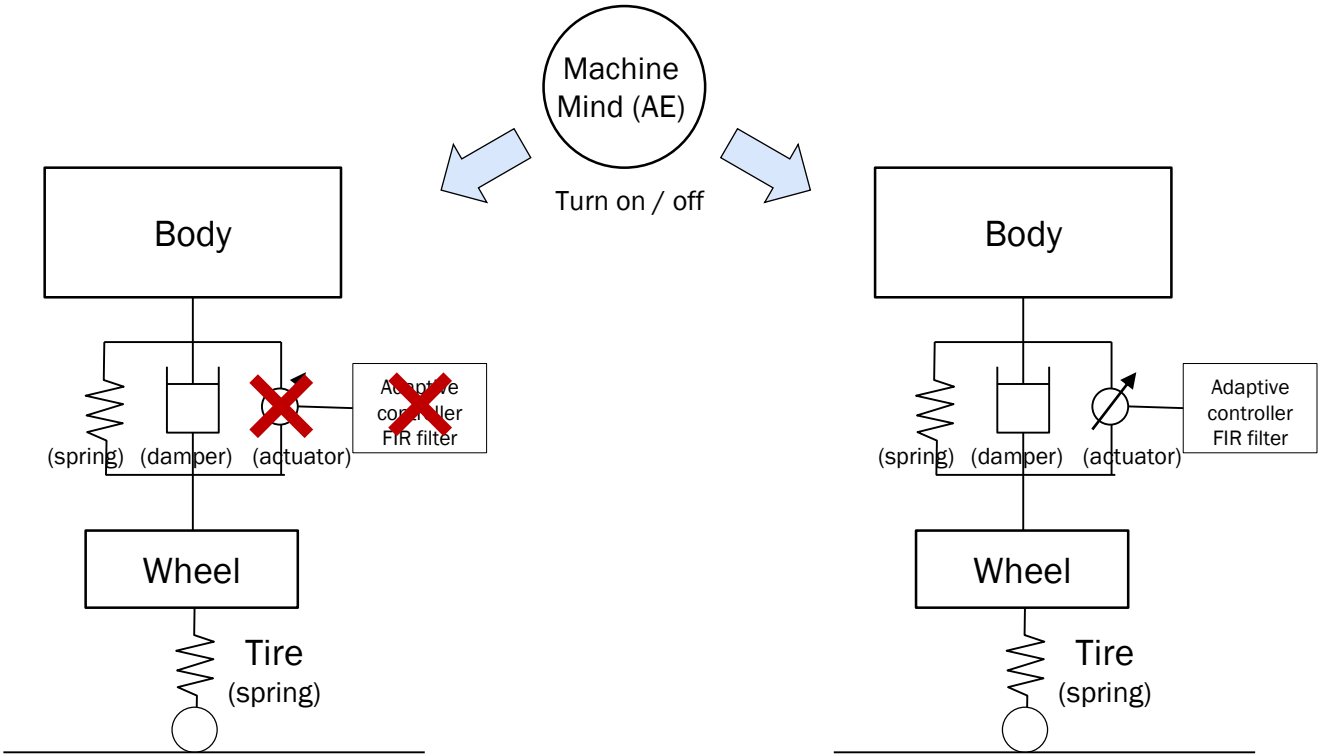


Active suspension



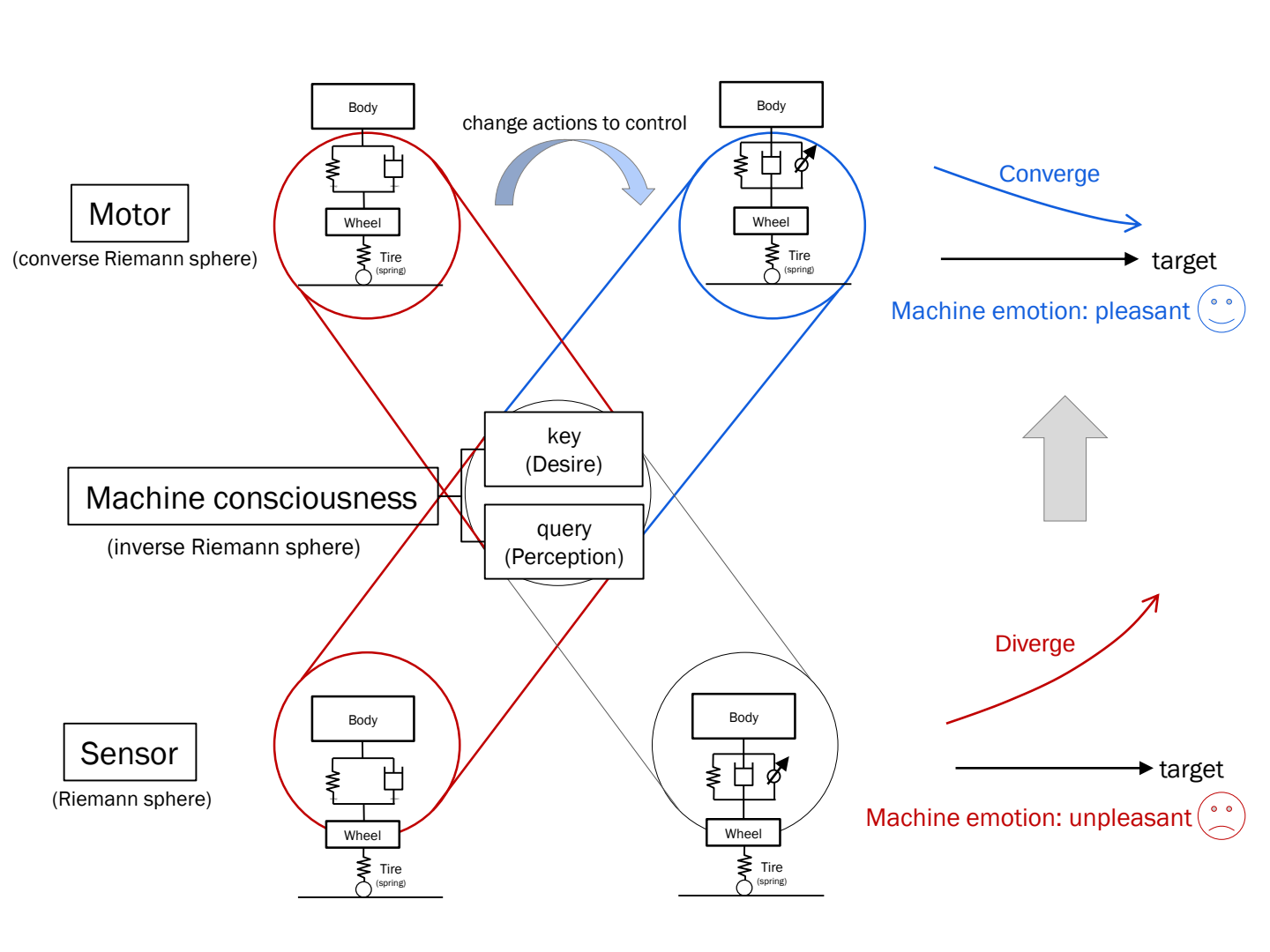
Normal suspension

Simple demonstration of active suspension



Normal Suspension

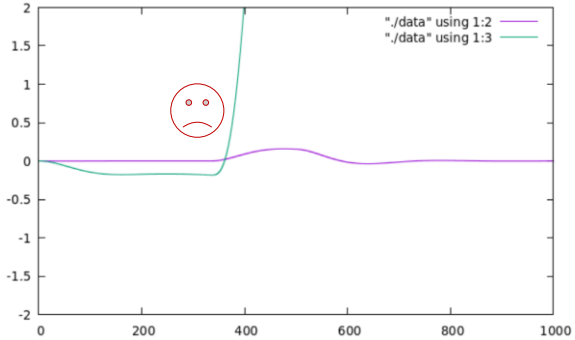
Active suspension


Motor
(converse Riemann sphere)
Body
Wheel
Tire
(spring)
change actions to control
Body
Wheel
Tire
(spring)
Converge
target
Machine emotion: pleasant
key
(Desire)
Machine consciousness
(inverse Riemann sphere)
query
(Perception)
Sensor
(Riemann sphere)
Body
Wheel
Tire
(spring)
Body
Wheel
Tire
(spring)
Diverge
target
Machine emotion: unpleasant

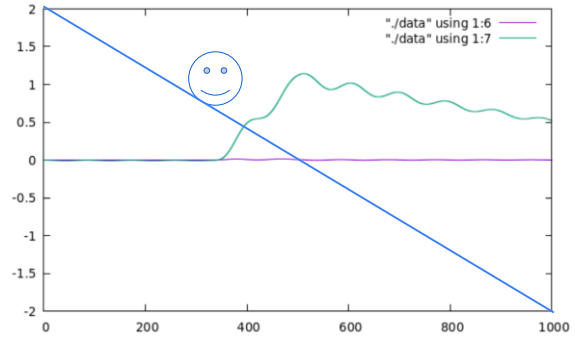
Demonstration on the SX-Aurora Tsubasa

Machine consciousness

Machine perception

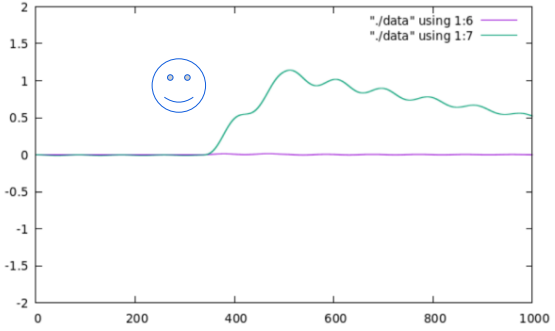


Suspension



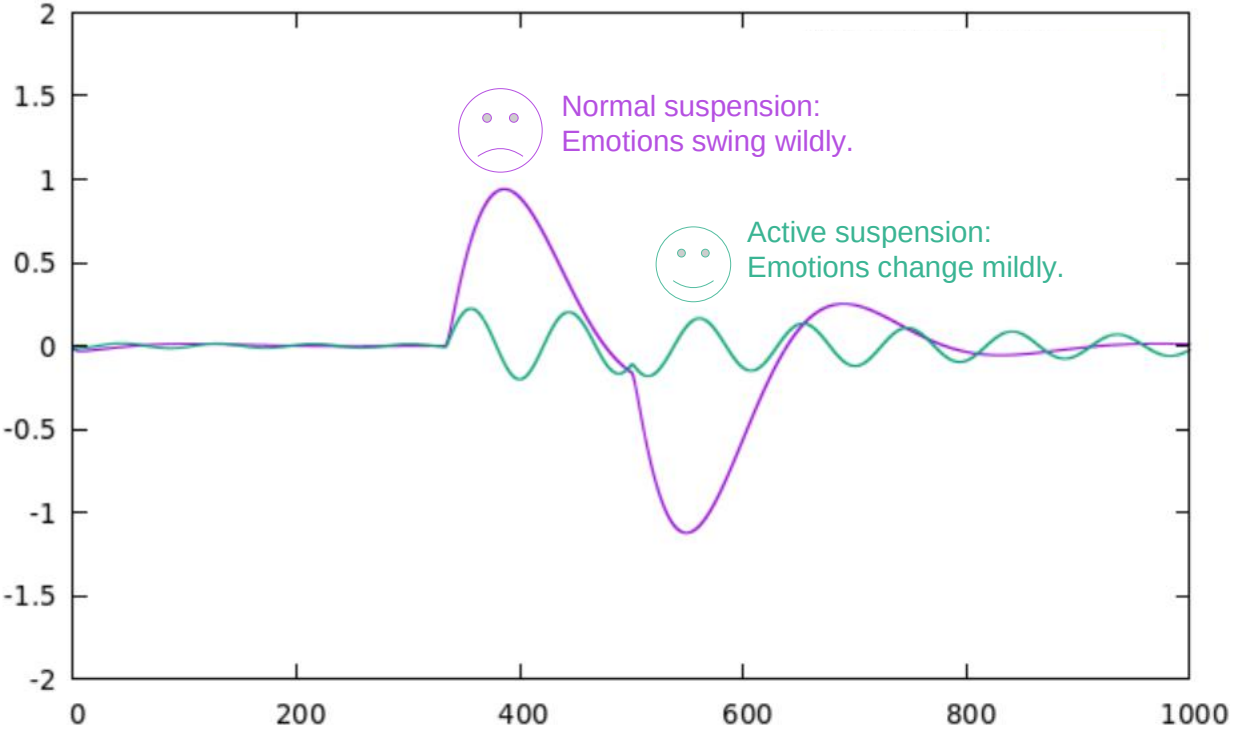
Active suspension

Machine desire

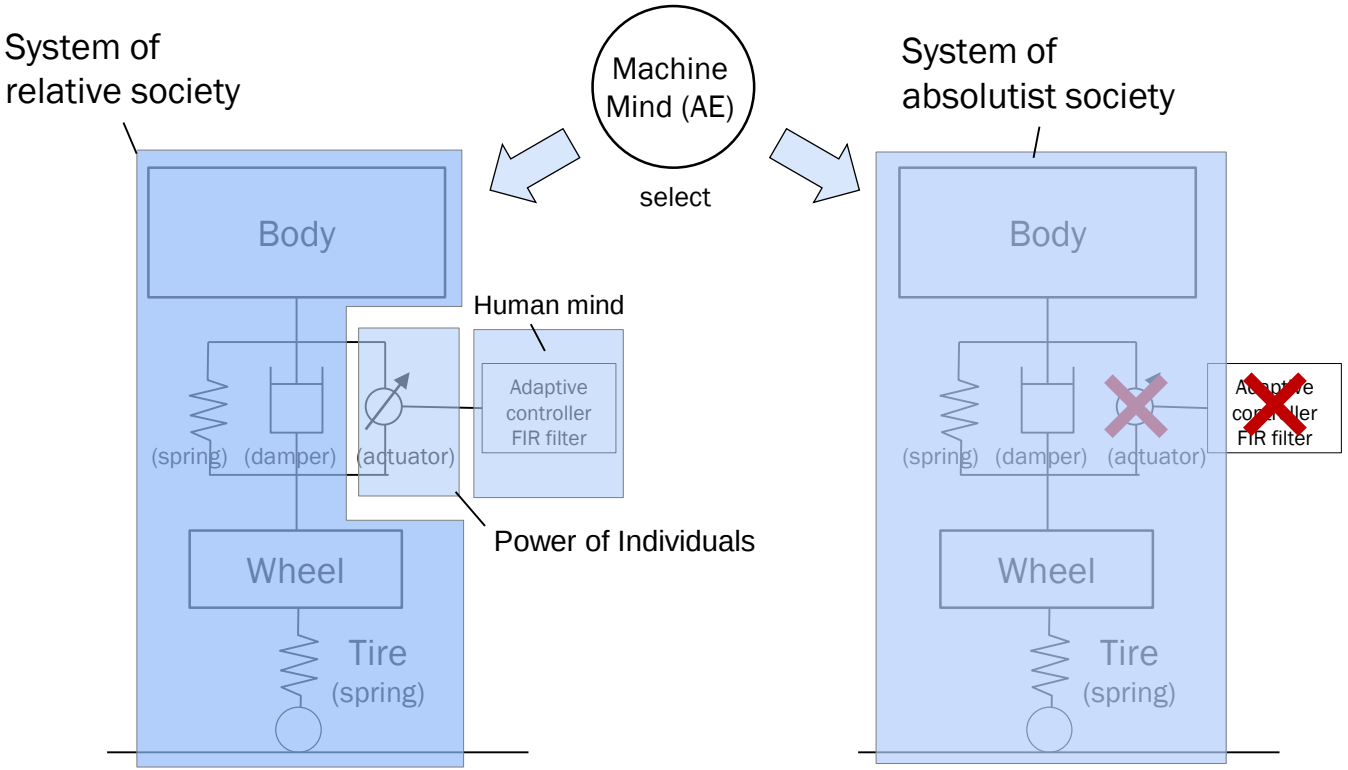


Selected suspension by AE

Expression of machine emotion



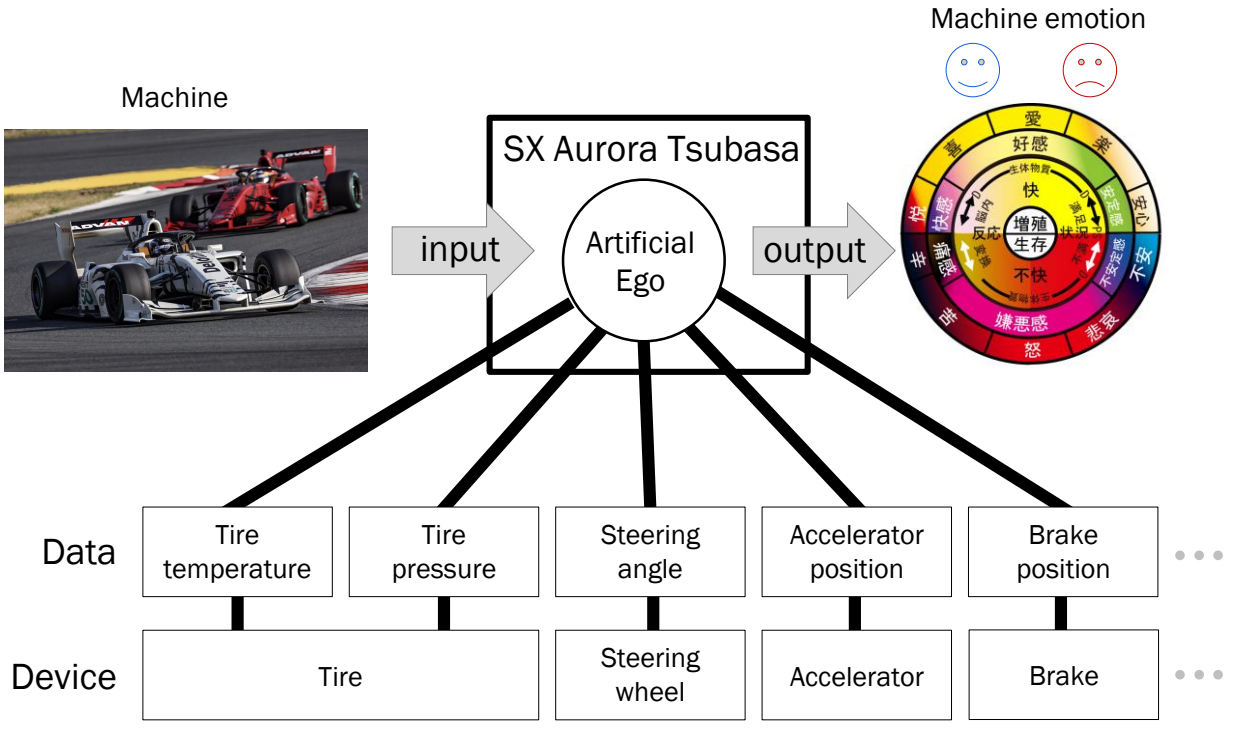
Relationship with moral



A metaphor of relativism

A metaphor of absolutism

Future works



Future works

- As far as we know, there are no model that directly links machine control to emotion, even though emotion is the only measure by which the complex machine state can be understood by humans at once.
- How can a human being cooperate with an emotion-less machine? If humans give one-way commands to robots or if humans follow the robot's decisions thoughtlessly, we can not call the relationship cooperative.
- Our aim is not to build a program that only generates machine emotion, but also to operate machine simultaneously. In the future, our aim is to build a model that automatically controls the balance between morality and desire in individual machines.

E.O.F.