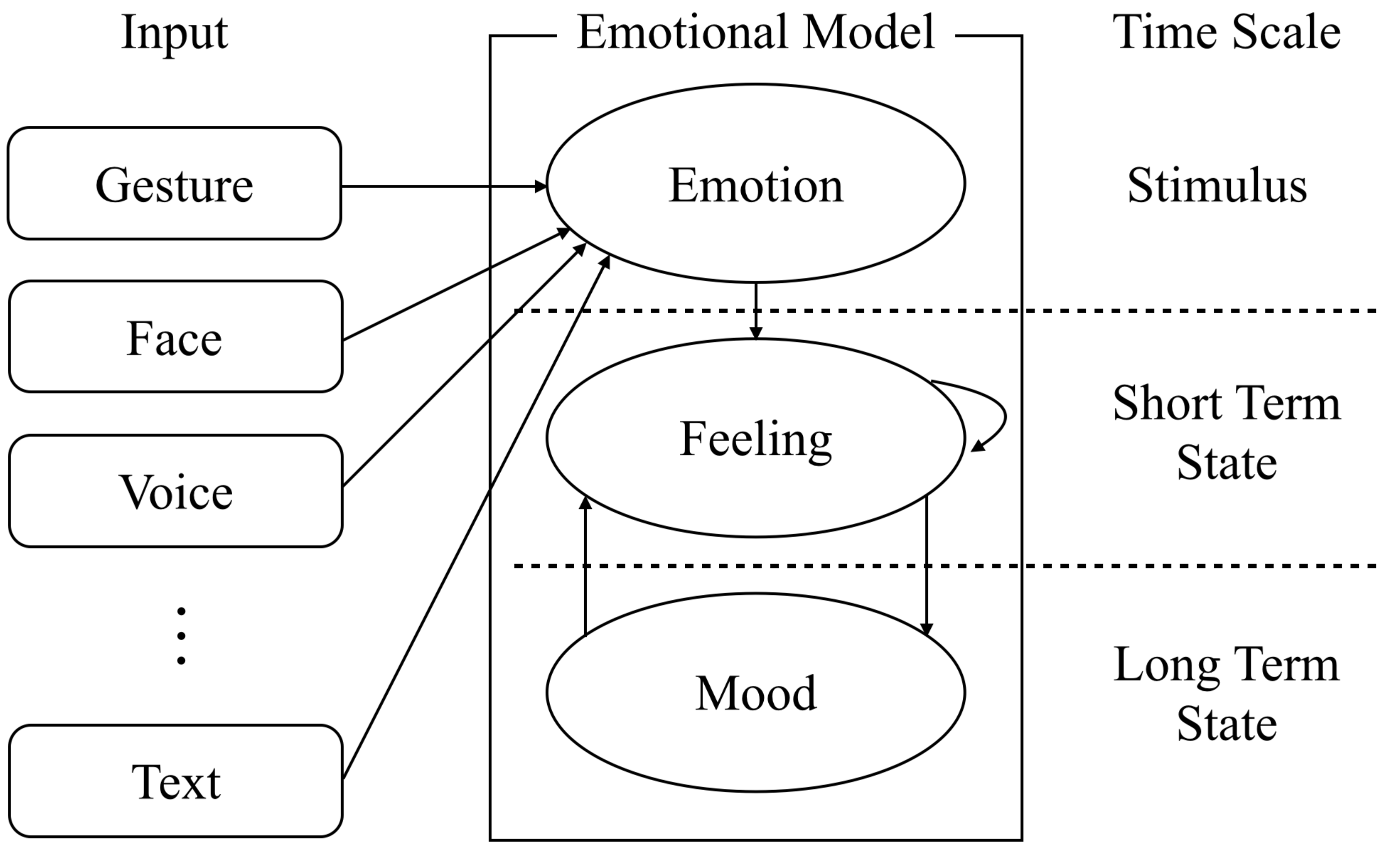
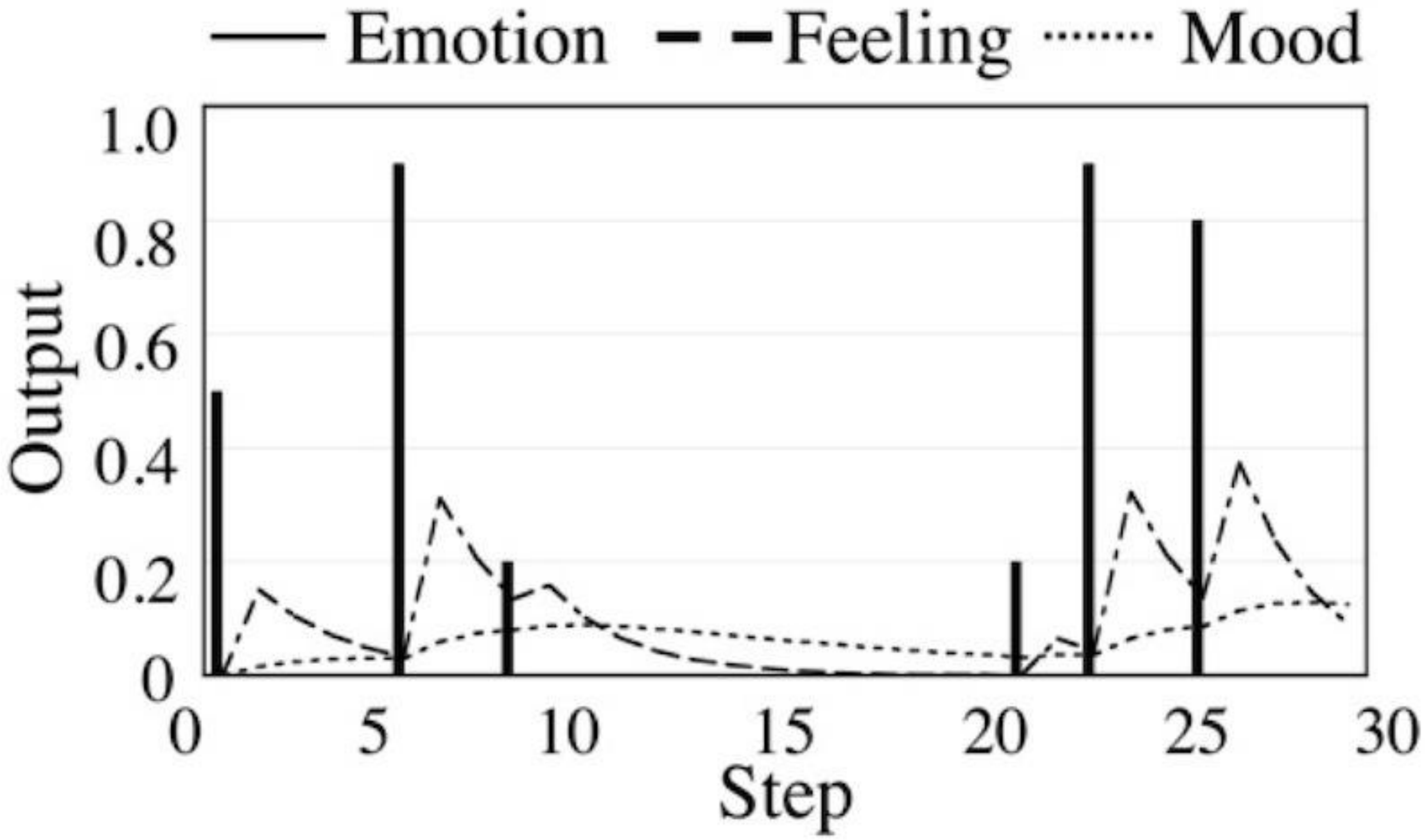
Emotional model

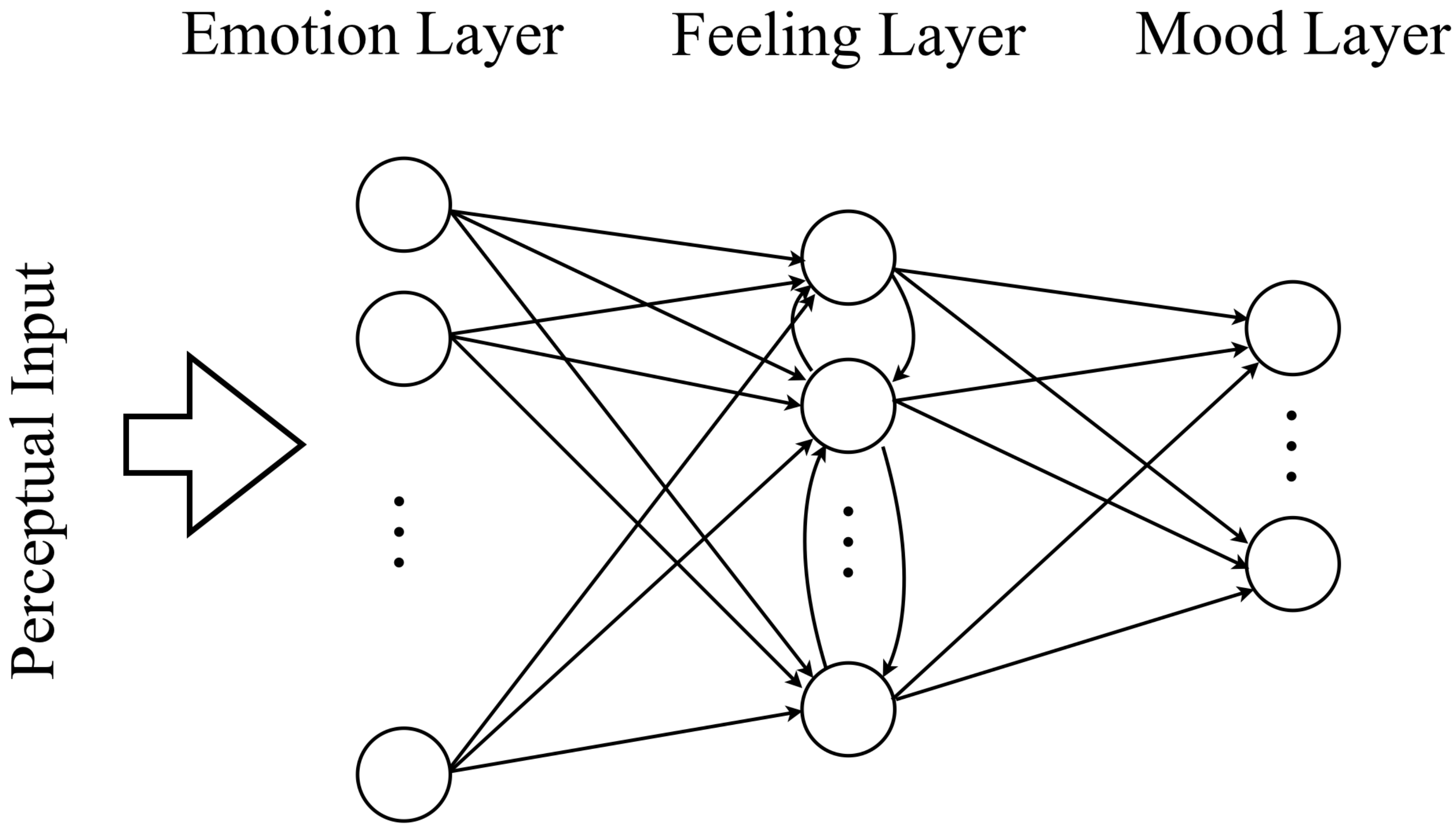
Emotional Model



Emotional Model



Spiking Neural Network



Spiking Neural Network

- Emotion Layer

$$h_i^{E-syn}(t) = \gamma^{E-syn} \cdot h_i^E(t-1)$$

- Feeling Layer

$$h_i^{F-ext}(t) = \sum_{j=1}^{N_E} w_{j,i}^E \cdot h_j^{E-PSP}(t-1)$$

- Mood Layer

$$h_i^{M-ext}(t) = \sum_{j=1}^{N_F} w_{j,i}^M \cdot h_j^{F-PSP}(t-1)$$

$$h_i^{M-syn}(t) = \gamma^{M-syn} \cdot h_i^M(t-1)$$

Weight Learning

- The weights between the emotion neurons and feeling neurons ($w^E_{j,i}$) are predefined and constant. These weights describe the relationship between the perception and feeling, they realize the intention of the emotional model.
- The weights between the feeling neurons and mood neurons ($w^M_{j,i}$) can be initialized based on a given scenario, and later they can be adjusted dynamically by Hebbian learning
- The weights between the feeling neurons ($w^F_{j,i}$) are initialized to 0, and they can be adjusted dynamically by Hebbian learning. If the condition

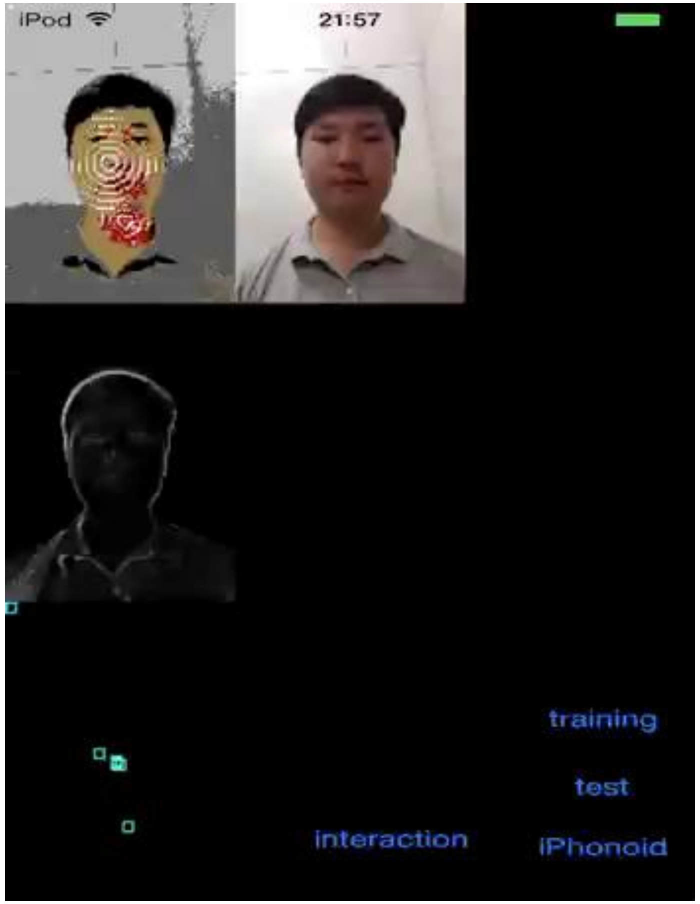
  $0 < h_j^{F-PSP}(t-1) < h_i^{PSP}(t)$ is satisfied:

$$w_{j,i}^F \leftarrow \tanh\left(\gamma^{wgt} w_{j,i}^F + \xi^{wgt} h_j^{F-PSP}(t-1) h_i^{F-PSP}(t)\right)$$

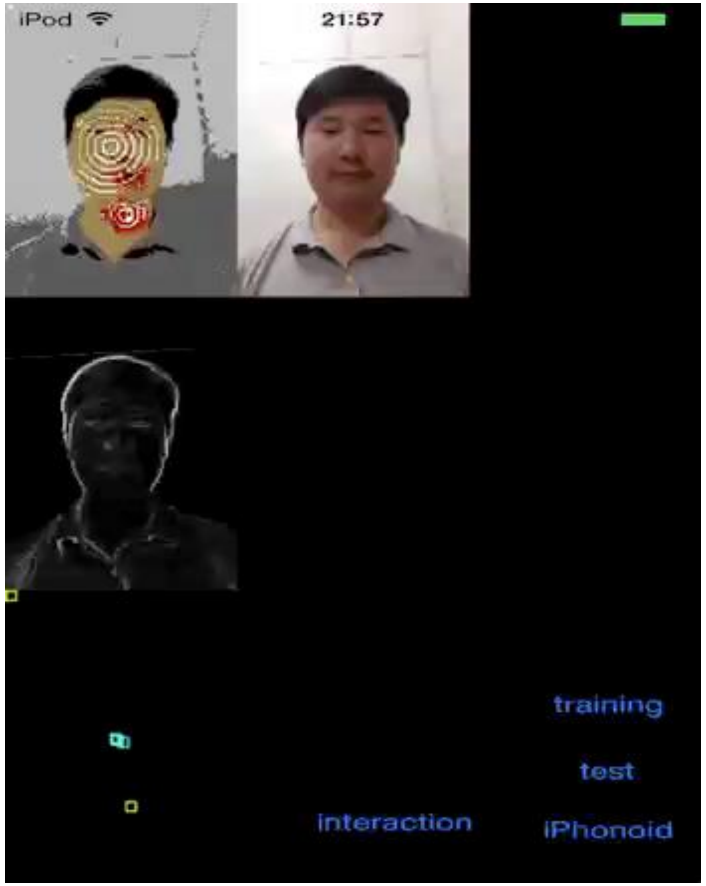
Experimental results

- Four basic training data
  - (1) moving the head up and down (we assume it means “yes”)
  - (2) moving the head left and right (we assume it means “no”)
  - (3) moving the hand up and down (we assume it means “come here”)
  - (4) moving the hand left and right (we assume it means “good bye”)

Head up and down

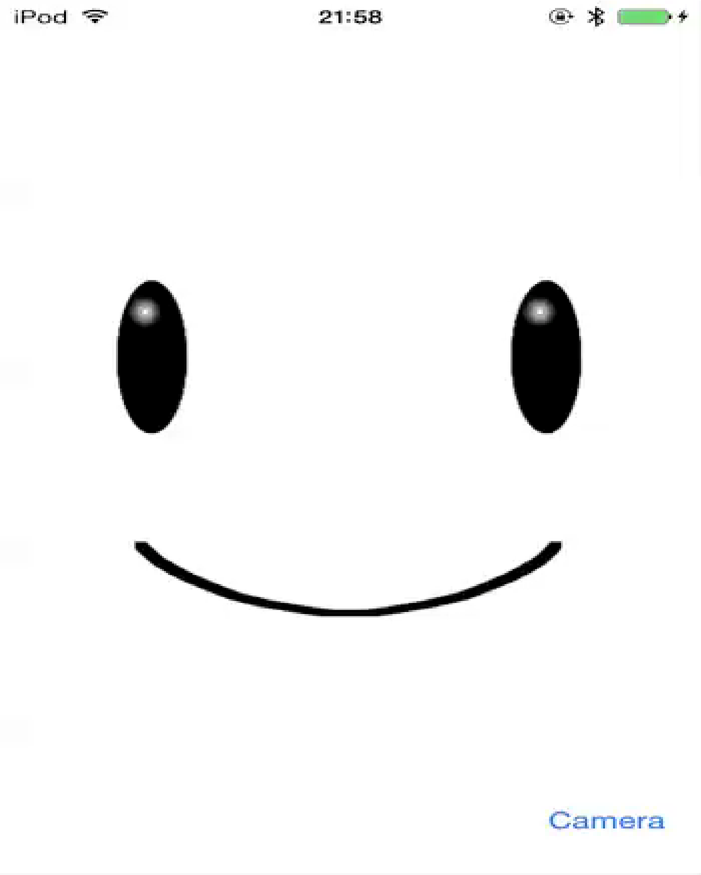


Head left and right



Hand up and down

Hand left and right



Initialization of weights W^E and $W^{\boldsymbol{M}}$

WEIGHTS BETWEEN EMOTION AND FEELING LAYER ($w^E_{j,i}$)

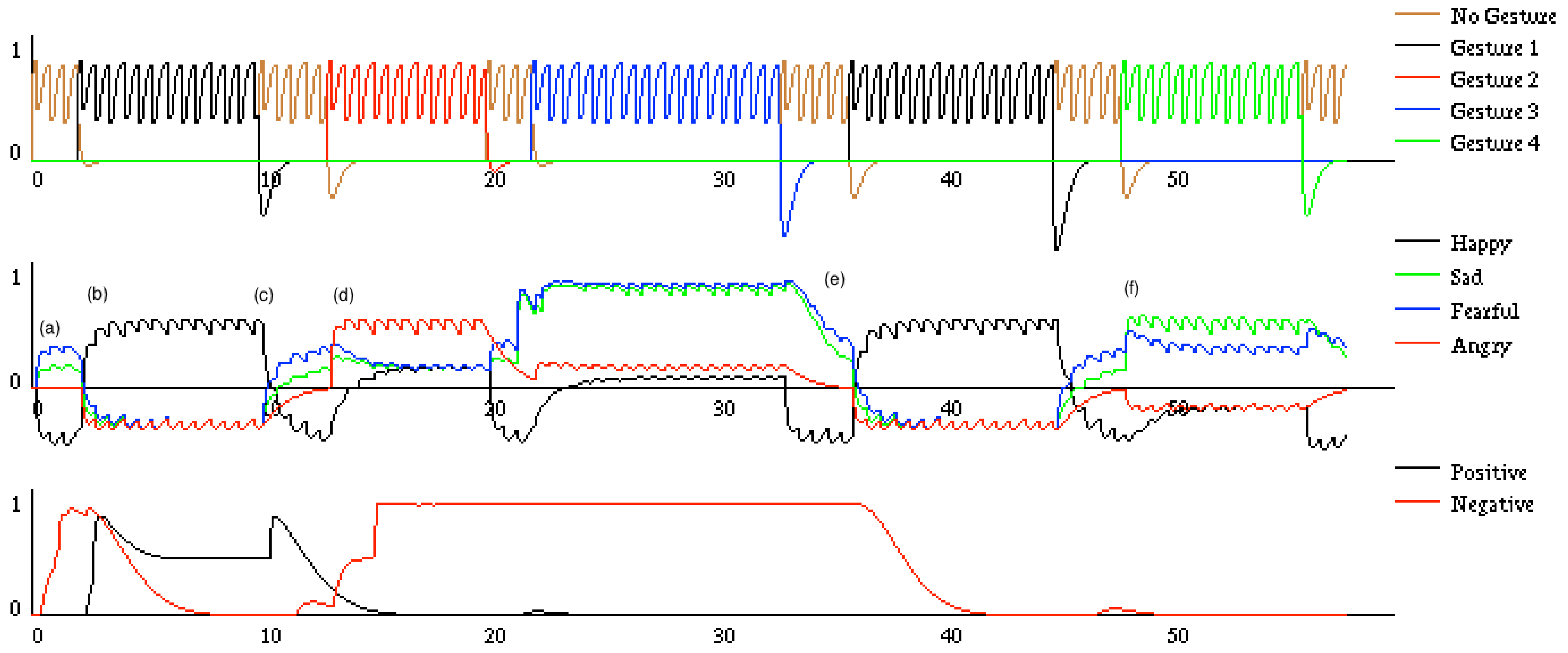
Input	Happy	Sad	Fearful	Angry
No gesture	-0.3	0.1	0.2	0
Gesture 1	0.4	-0.2	-0.2	-0.2
Gesture 2	0.1	0.1	0.1	0.4
Gesture 3	0.05	0.2	0.4	0.1
Gesture 4	-0.1	0.4	0.2	-0.1

The initial weight between *happy* and *positive mood* is 0.1, while it is also 0.1 between the other feelings and the *negative mood*

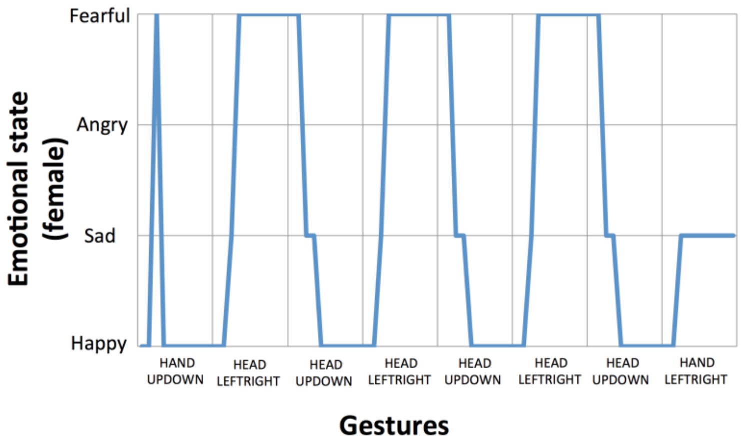
TABLE II. PARAMETER SETTING FOR SNN

N_E	γ^{E-syn}	γ^{E-PSP}	γ^{E-ref}	R_E	θ_E
5	0.55	0.9	0.7	1	0.85
N_F	γ^{F-syn}	γ^{F-PSP}	γ^{F-ref}	R_F	θ_F
4	0.6	0.9	0	0	0.2
N_M	γ^{M-syn}	γ^{M-PSP}	γ^{M-ref}	R_M	θ_M
2	0.9	0.98	0	0	0.2
γ^{wgt}	0.7		ξ^{wgt}	0.9	

Experimental results



Experimental results



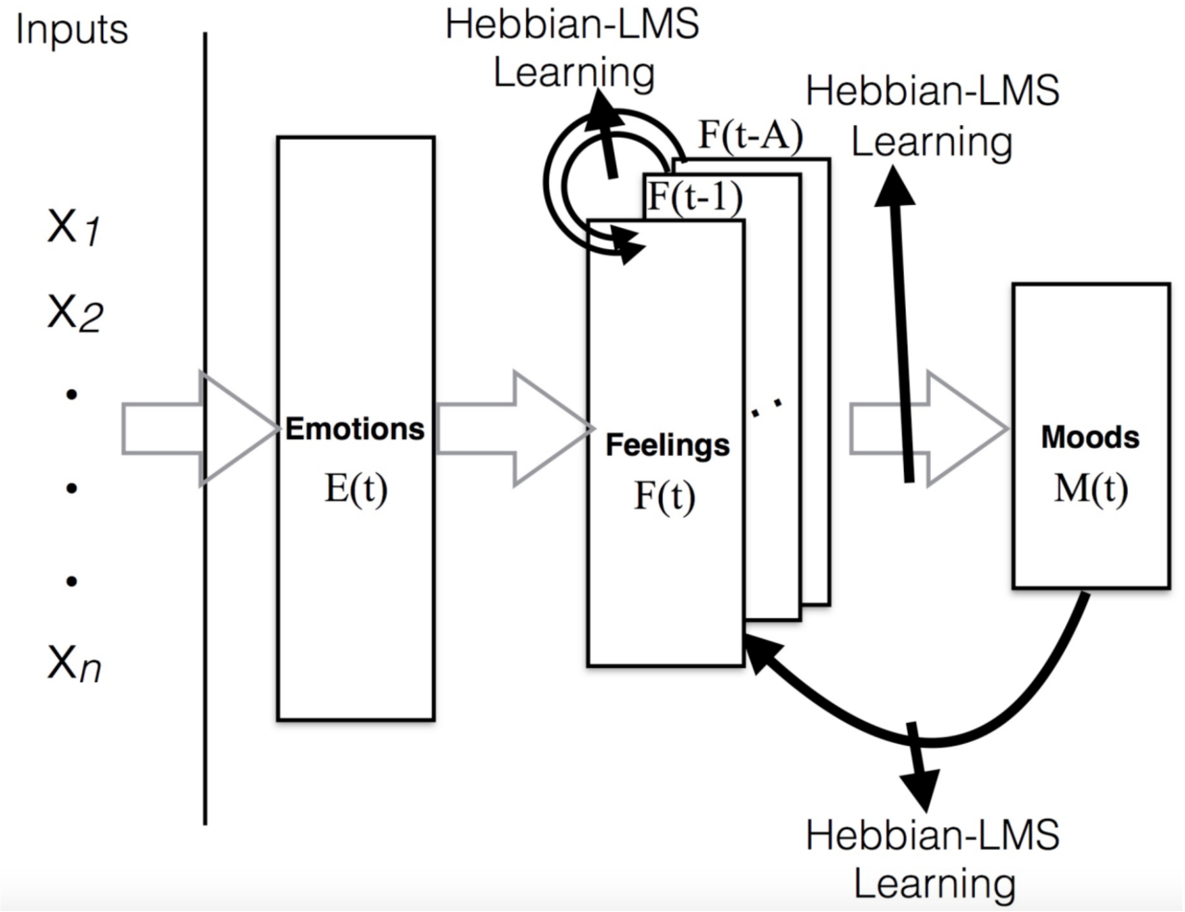
- Gesture 1 (head up down, “yes”):
- male user: the robot is happy
- female user: the robot is happy

- Gesture 2 (head left right, “no”)
- male user: the robot is sad
- female user: the robot is fearful

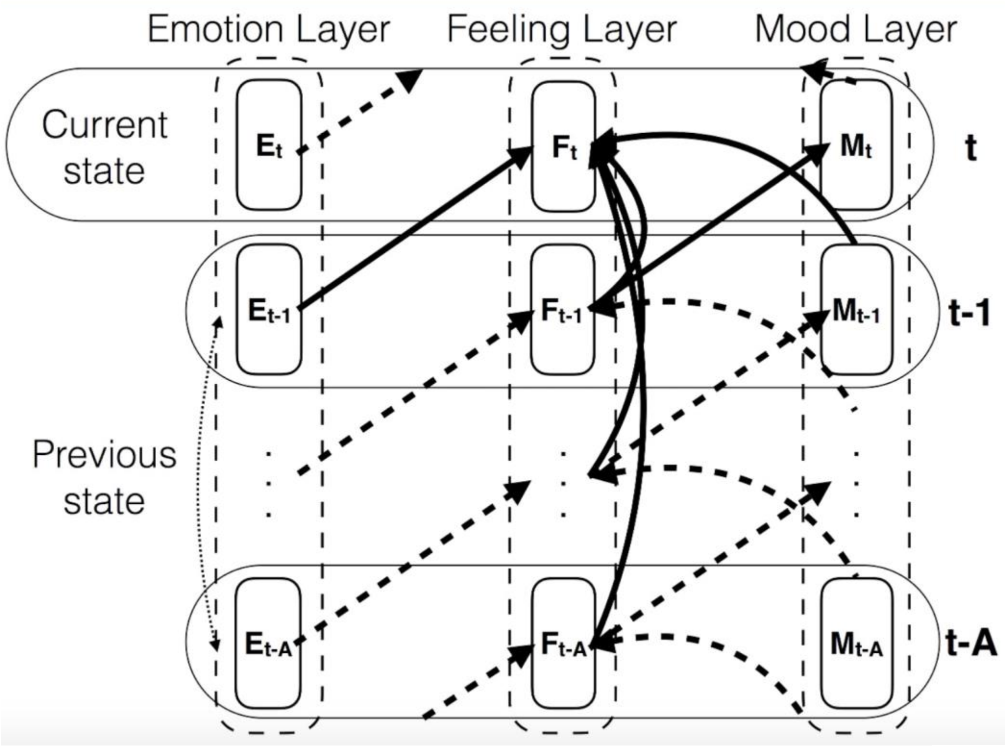
- Gesture 3 (hand up down, “come here”)
- male user: the robot is fearful
- female user: the robot is happy

- Gesture 4 (hand left right, “good bye”)
- male user: the robot is sad
- female user: the robot is sad

New model: Recurrent Simple Spike Response

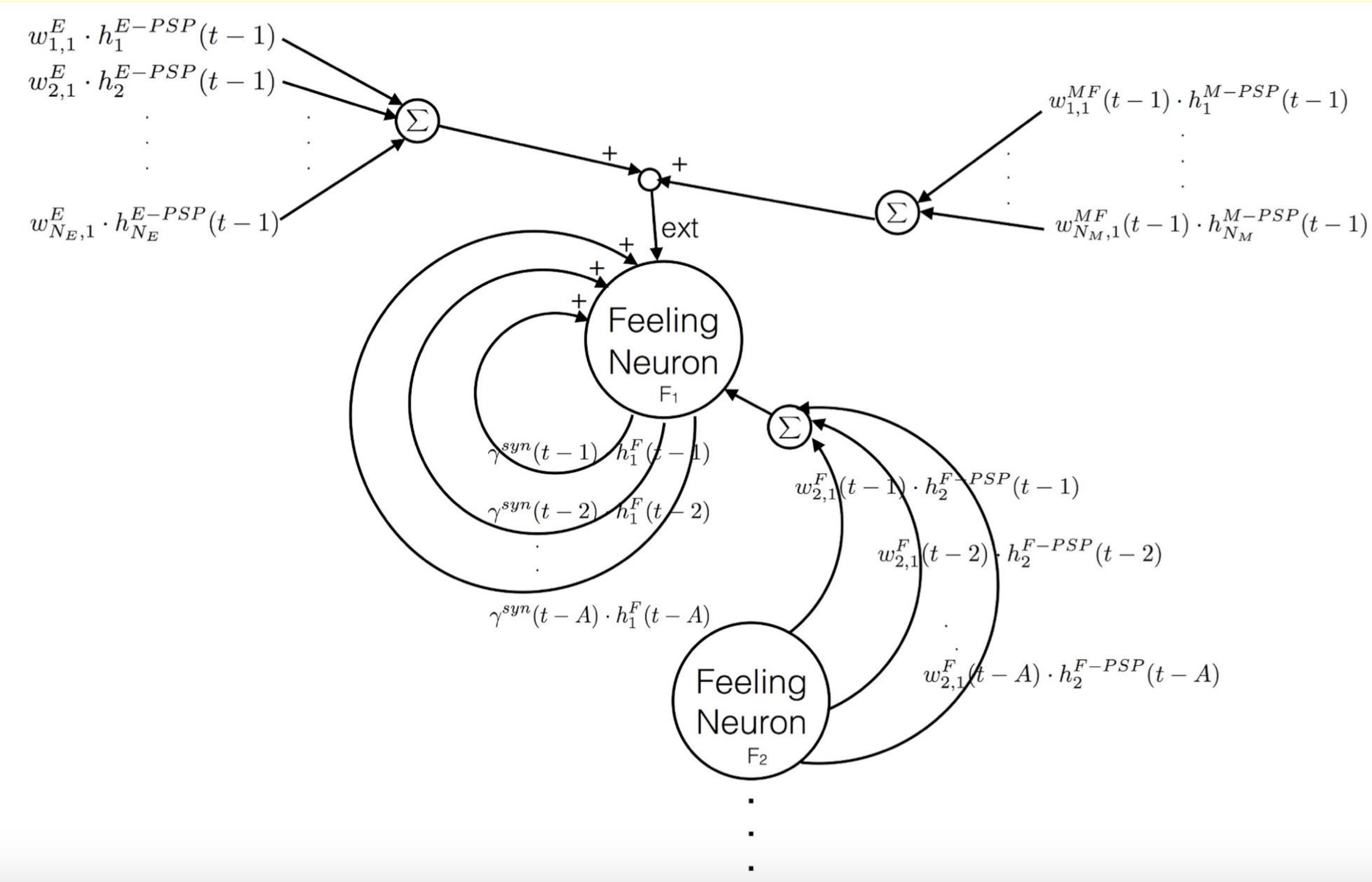


Structure of the Recurrent State



$$h_i^{syn}(t) = \sum_{a=1}^{A} \left(\gamma^{syn}(t-a) \cdot h_i(t-a) + \sum_{j=1, i \neq j}^{N} w_{j,i}(t-a) \cdot h_j^{PSP}(t-a) \right)$$

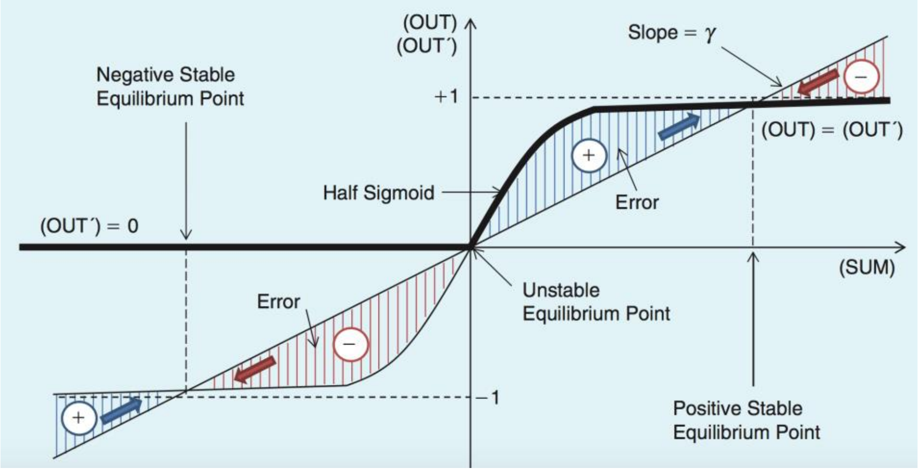
Connections to Feeling Neurons



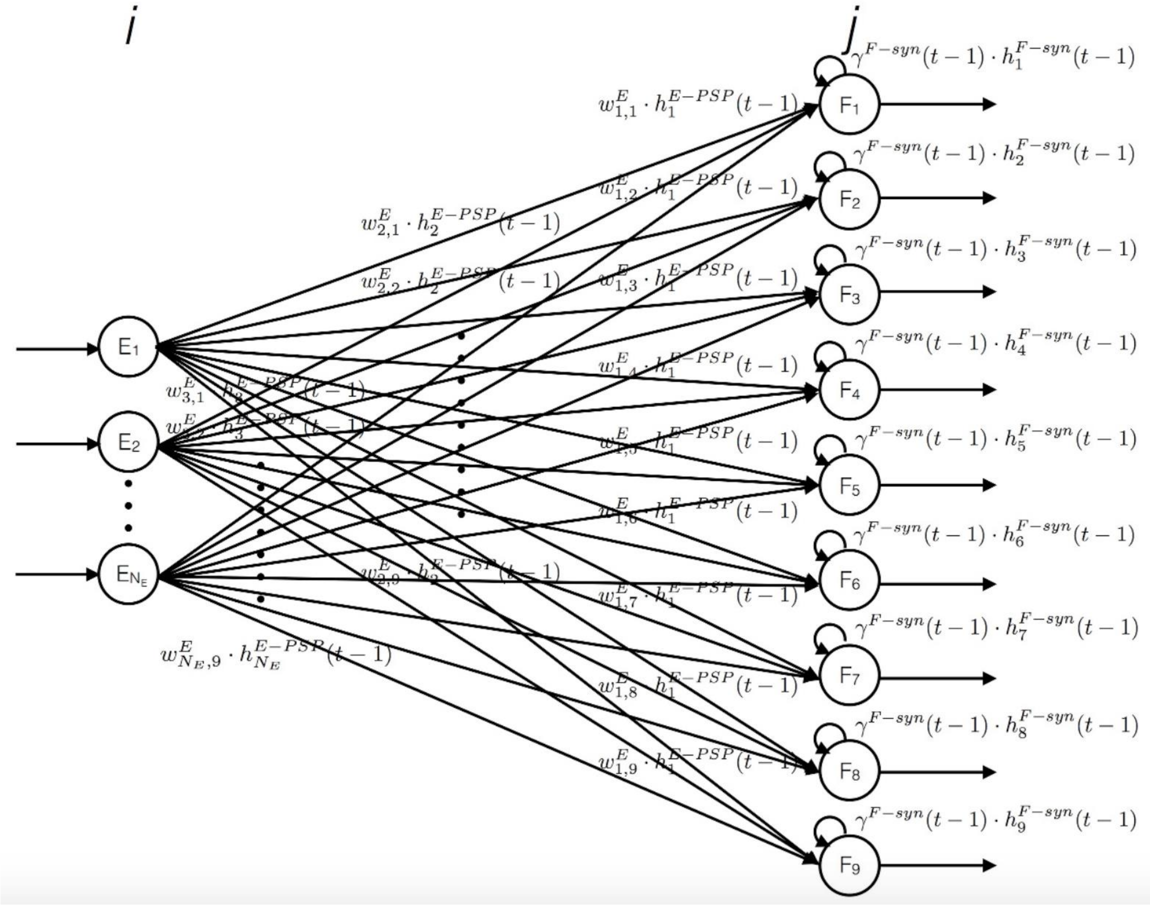
Weight Learning by Hebbian-LMS Algorithm

$$W_{k+1} = W_k + 2\mu e_k X_k$$
$$e_k = SGM\left(X_k^T W_k\right) - \gamma X_k^T W_k = SGM\left((SUM)_k\right) - \gamma (SUM)_k$$

$$W(t) = W(t-1) + Z \circ X_{input}(t-1)$$
$$Z = \xi^{wgt}\left(\tanh\left(SUM_{input}\right)\right) - \gamma^{wgt} \cdot \left((SUM)_{input}\right)$$

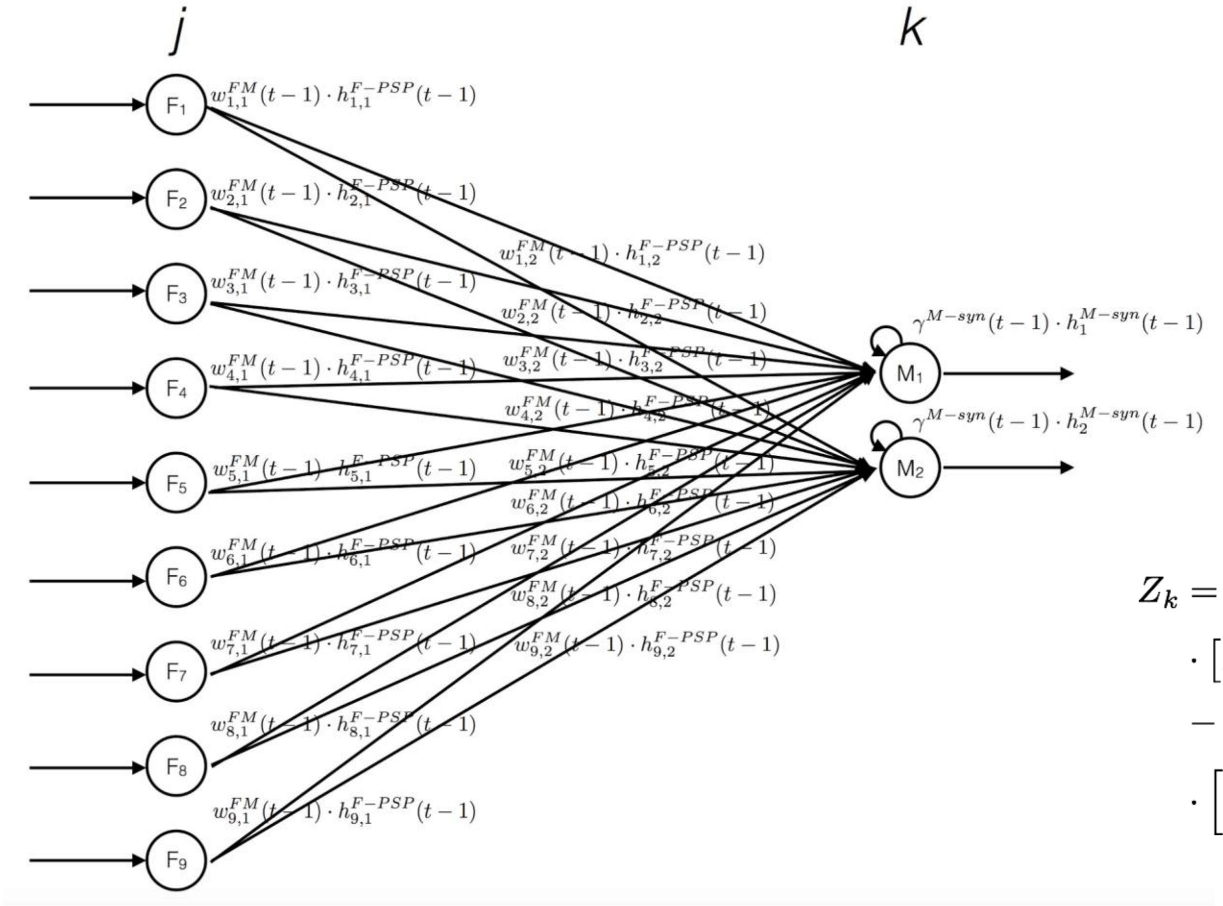


Learning Weight: W^E



$$w_{g,j}^E = \frac{w_{g_{feeling},j}^E + w_{g_{battery},j}^E + w_{g_{distance},j}^E + w_{g_{gender},j}^E}{4}$$

Learning Weight: W^{FM}



$$W_{j,k}^{FM}(t) = W_{j,k}^{FM}(t-1) + Z_k \circ X_{input}^{FM}(t-1)$$

$$\begin{aligned} Z_k = \xi^{wgt} \cdot tanh\big(&[w_{1,k}^{FM}(t-1), \cdots, w_{9,k}^{FM}(t-1), \gamma^{M-syn}(t-1)]\big) \\ &\cdot [h_{1,k}^{F-PSP}(t-1), \cdots, h_{9,k}^{F-PSP}(t-1), h_k^{M-syn}(t-1)]^T \\ &- \xi^{wgt} \cdot \gamma^{wgt} \cdot [w_{1,k}^{FM}(t-1), w_{2,k}^{FM}(t-1), \cdots, w_{9,k}^{FM}(t-1), \gamma^{M-syn}(t-1)] \\ &\cdot \Big[h_{1,k}^{F-PSP}(t-1), h_{2,k}^{F-PSP}(t-1), \cdots, h_k^{M-syn}(t-1)\Big]^T \end{aligned}$$

Learning Weight: W^{MF} ,W^{F}

$$W_{k,j}^{MF}(t) = W_{k,j}^{MF}(t-1) + Z_j \circ X_{input}^{MF}(t-1)$$

$$Z_j = \xi^{wgt} \cdot \tanh\left(\left[w_{1,j}^{MF}(t-1), w_{2,j}^{MF}(t-1), \gamma^{F-syn}(t-1)\right]\right) \cdot \left[h_{1,j}^{M-PSP}(t-1), h_{2,j}^{M-PSP}(t-1), h_{3,j}^{F-syn}(t-1)\right]^T$$

$$W_{i,j}^{F}(t) = \sum_{a=1}^{A}\left(W_{i,j}^{F}(t-a) + Z_j(t-a) \circ X_{input}^{F}(t-a)\right)$$

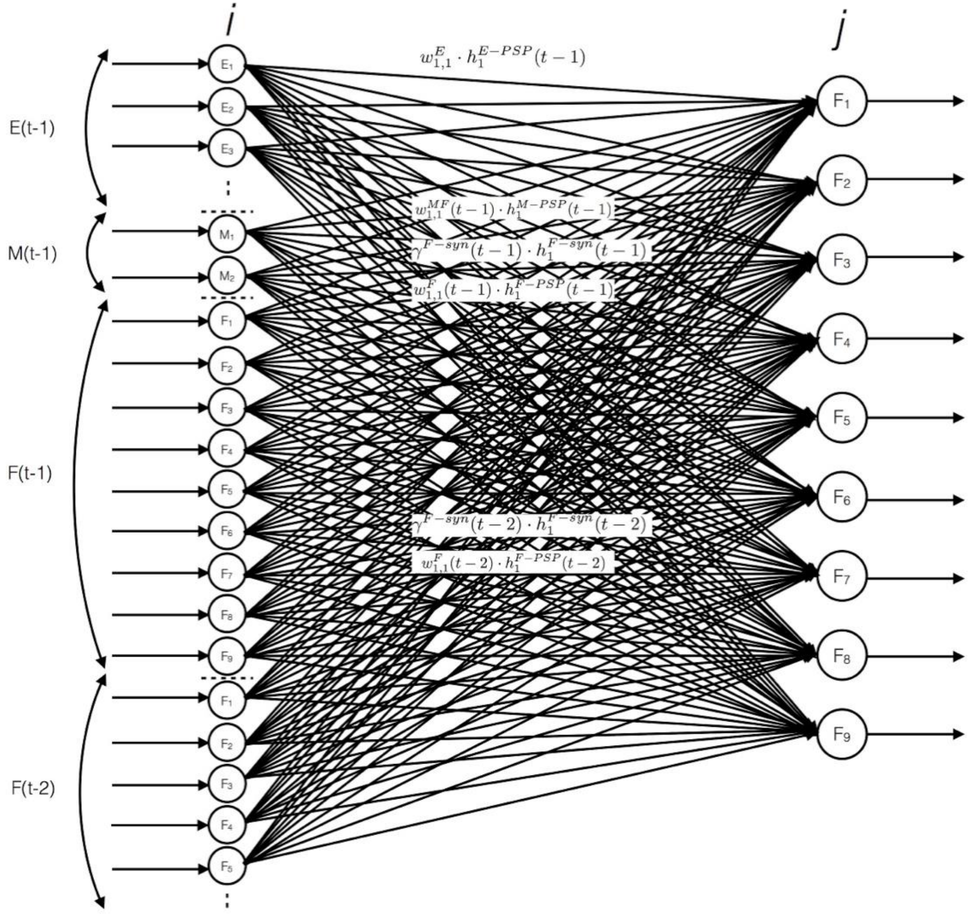
$$Z_{i,j}(t-a) = \xi^{wgt} \tanh\left(\left[w_{1,j}^{F}(t-a), .., w_{8,j}^{F}(t-a), w_{9,j}^{F}(t-a)\right] \cdot \left[h_{1,j}^{F}(t-a), .., h_{8,j}^{F}(t-a), h_{9,j}^{F}(t-a)\right]^T\right)$$
$$-\xi^{wgt} \cdot \gamma^{wgt} \cdot \left[w_{1,j}^{F}(t-a), .., w_{8,j}^{F}(t-a), w_{9,j}^{F}(t-a)\right] \cdot \left[h_{1,j}^{F}(t-a), .., h_{8,j}^{F}(t-a), h_{9,j}^{F}(t-a)\right]^T$$

$$h_{i,j}^{\phi}(t-a) = \begin{cases} h_{i,j}^{F-syn}(t-a) & if\ i=j \\ h_{i,j}^{F-PSP}(t-a) & otherwise \end{cases}$$

$$w_{i,j}^{\phi}(t-a) = \begin{cases} \gamma^{F-syn}(t-a) & if\ i=j \\ \gamma^{F-syn}(t-a) \cdot w_{i,j}^{F}(t-a) & otherwise \end{cases}$$

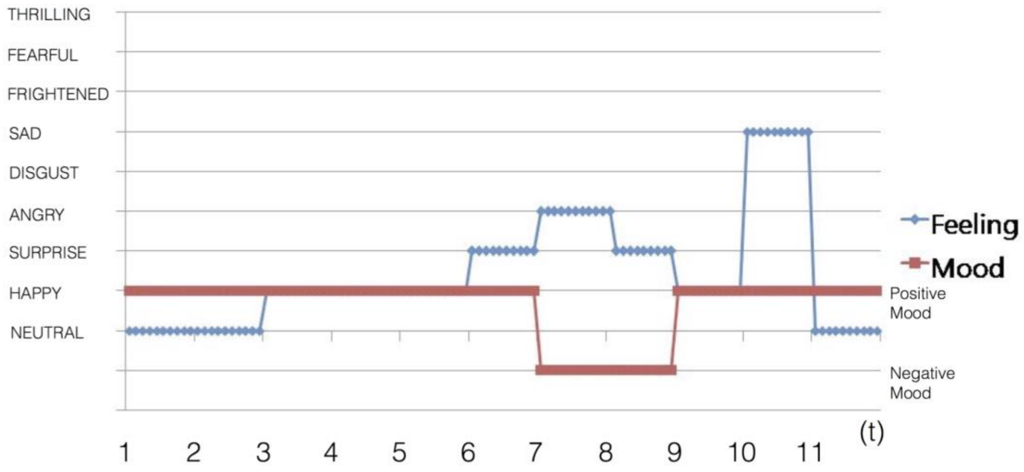
$$z_{i,j}(t-a) = \begin{cases} 0 & if\ i=j \\ z_{i,j}(t-a) & otherwise \end{cases}$$

The Structure of SNN



Experimental Result

(t)	Human emotional factor			Robot emotional factor		
	Gesture	Smiling	Adjective	Battery	Distance	Gender
1	None	None	None	Low	Far away	Woman · Man
2	None	None	None	Full	Close	Woman · Man
3	None	Smiling	None	Full	Close	Woman · Man
4	Up & Down	None	None	Full	Close	Woman · Man
5	None	Smiling	Happy	Full	Close	Woman · Man
6	None	None	Surprise	Full	Close	Woman · Man
7	None	None	Angry	Full	Close	Woman · Man
8	None	None	Surprise	Full	Close	Woman · Man
9	None	Smiling	Happy	Full	Close	Woman · Man
10	Left & Right	Smiling	None	Full	Close	Woman · Man
11	None	None	None	Full	Far away	Woman · Man



Behavior generation

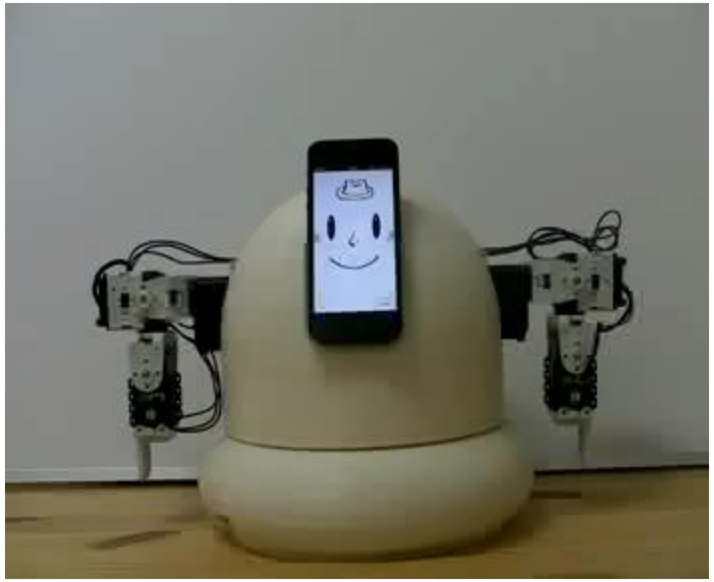
Face and gesture expressions

- Robot partners can encourage elderly people to communicate with others
- Nonverbal communications such as facial expressions, and emotional gestures should also be understood and expressed by the robot
- We propose a facial and gestural expression system, which uses the robot’s emotional state as an input
- Gesture expression is proposed without any pre-programmed information
- Laban movement analysis and interactive evolution strategy are applied in the gesture generation

iPhonoid-B

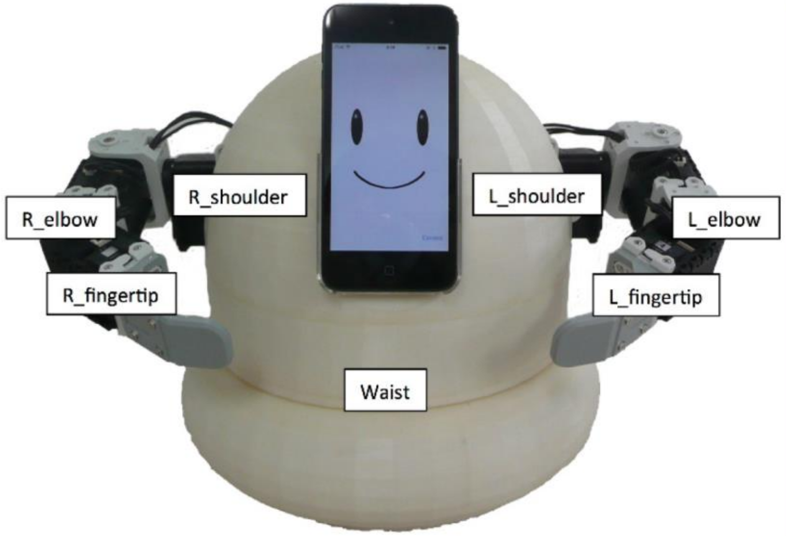
- The predefined gestures of iPhonoid-B had many problems:
  - It takes time to make a gesture for the robot
  - Discontinuous behavior during the action
  - It repeats the same gesture

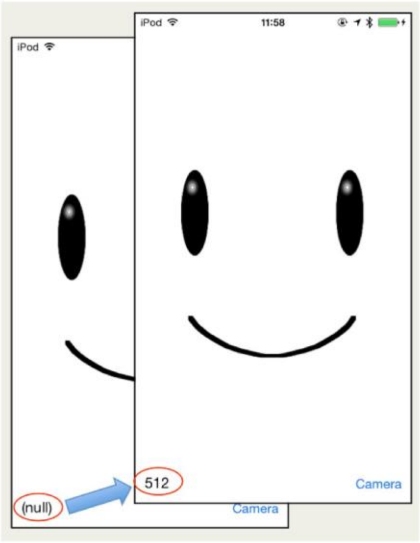
→ We need natural gesture making based on the emotional state

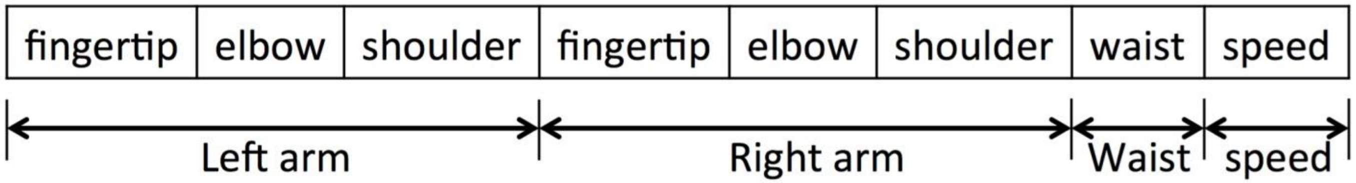


Previous iPhonoid structure and movements

Servo Motor for Gesture Expression







Gesture Generation based on Laban Theory

- Laban Movement Analysis (LMA) is a theory to describe and interpret various human movements
- LMA describes 4 movement components: Body, Effort, Shape, Space
- Efforts express subjective inner intention
- Effort has 4 dimensions each one having two polarities

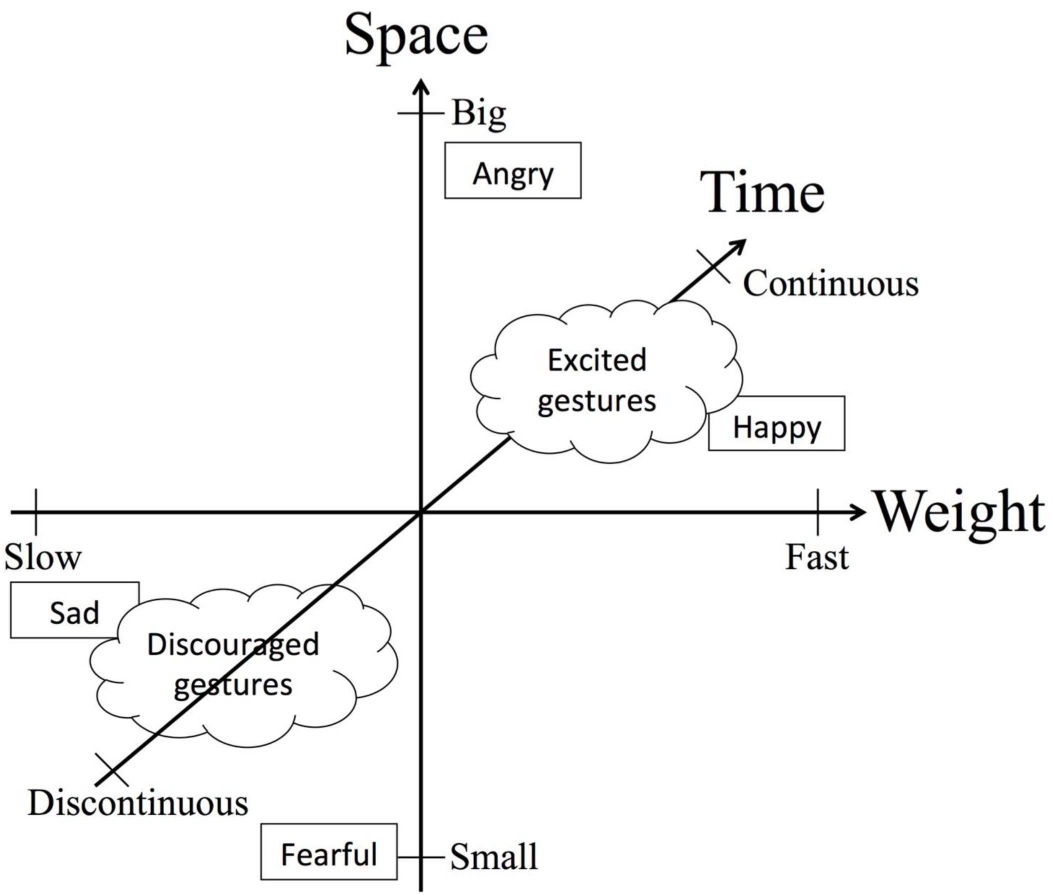
Effort Factor	Effort element (Indulging polarity)	Effort element (Fighting polarity)
Space	Flexible	Direct
Weight	Light	Strong
Time	Sustained	Quick
Flow	Free	Bound

Gesture Generation based on Laban Theory

- The combination of two effort factors is a state
- The combination of three effort factors is a drive
- Action drive combines: Space, Weight, Time

Expression method	
Weight	Speed of motors
Time	Interval of timing
Space	Angle of each joint

Gesture Generation based on Laban Theory

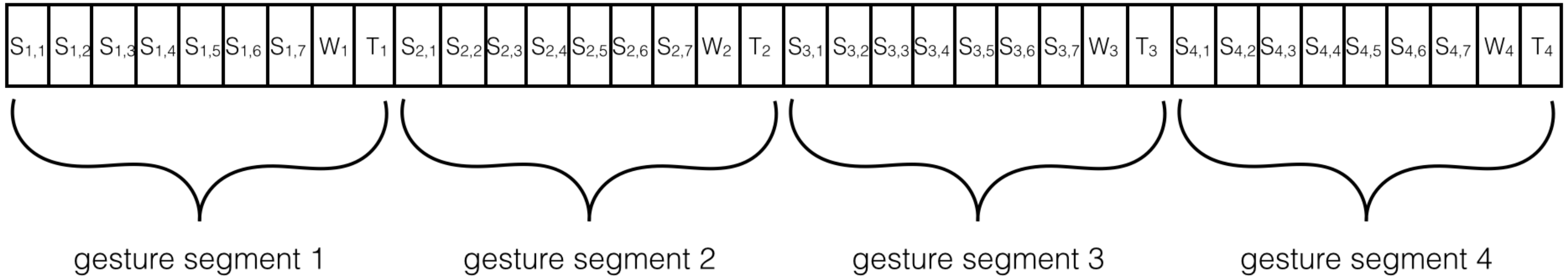


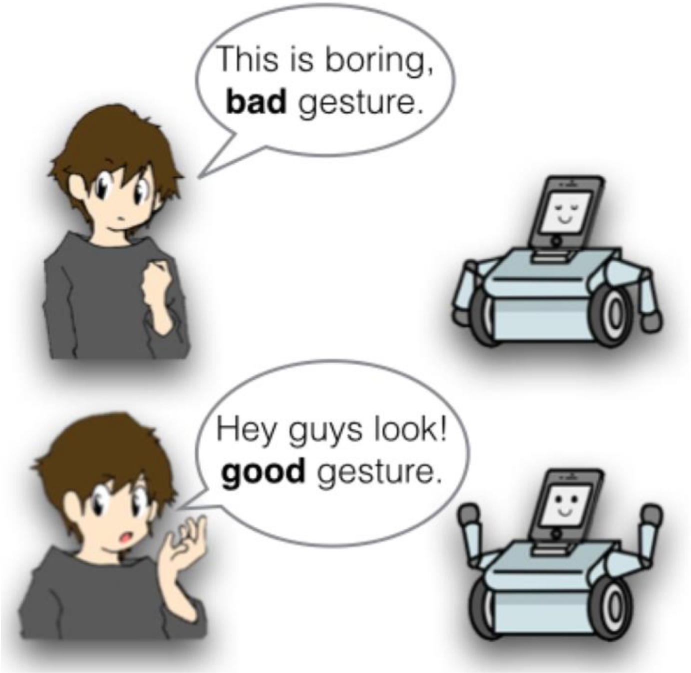
Gesture Generation based on Laban Theory

	Happy	Sad	Angry	Fearful
Weight	Fast	Slow	Middle	Middle
Time	Continuous	Discontinuous	Continuous	Discontinuous
Space	Middle	Middle	Big	Small

	Happy	Sad	Angry	Fearful
Weight	0.5–1.0	0–0.5	0.3–0.7	0.3–0.7
Time	0–0.5	0.5–1.0	0–0.5	0.5–1.0
Space	0.3–0.7	0.3–0.7	0.5–1.0	0–0.5

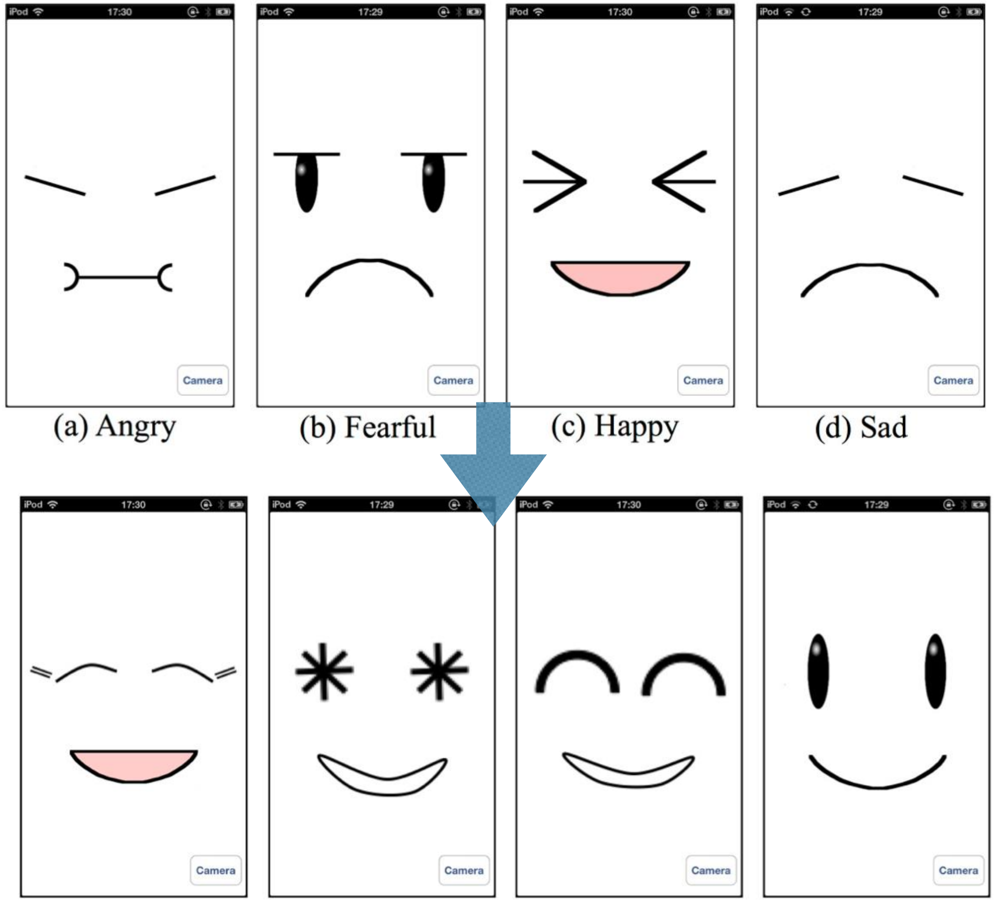
Gesture Optimization by Interactive Evolution Strategy





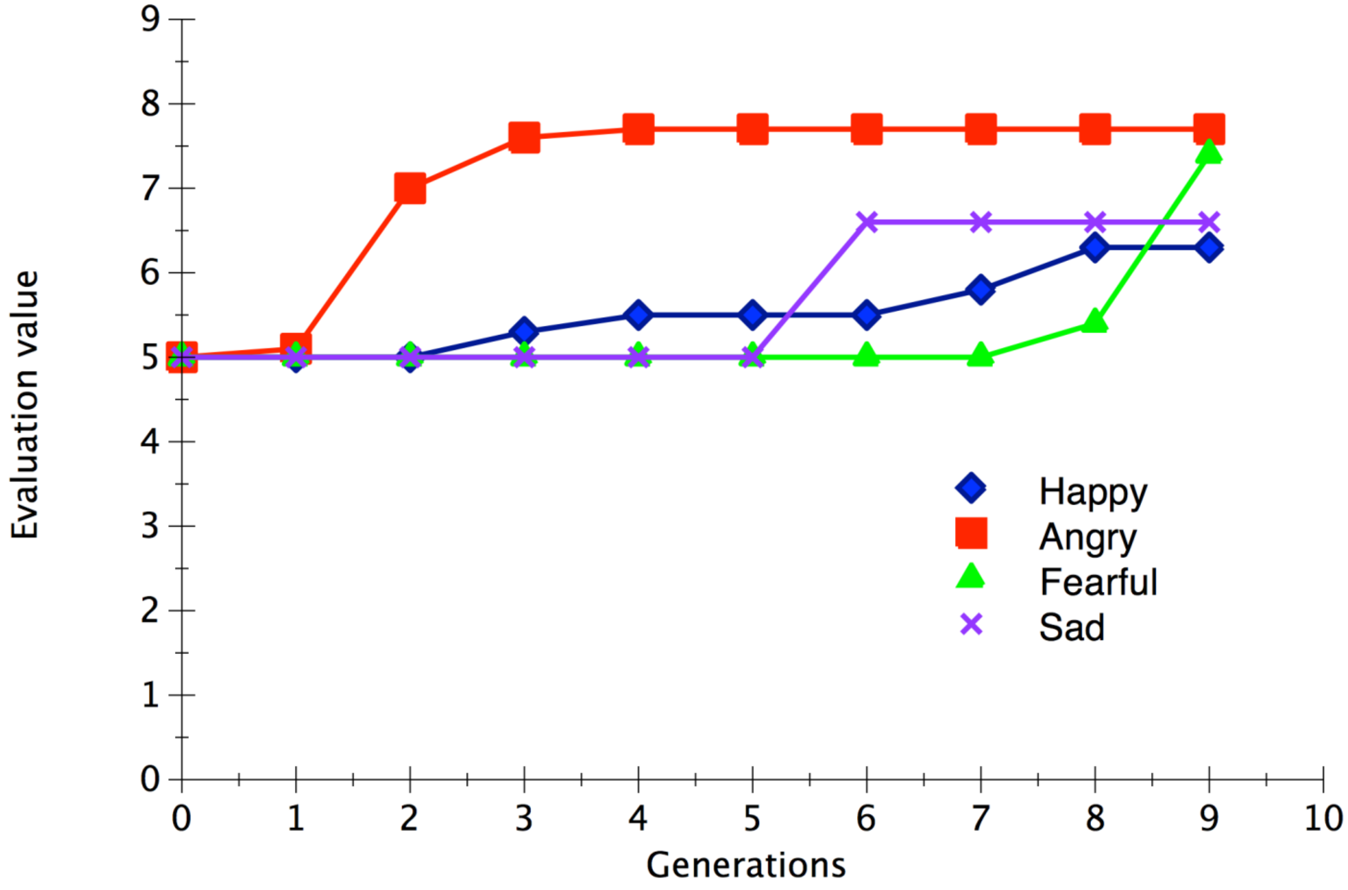
- A simple (1+1)-ES approach is applied where 1 parent competes with its mutated offspring, and the fittest one will survive to the next generation
- The mutation in the offspring is performed by as follows: $\boldsymbol{x}_{t+1} = \boldsymbol{x}_t + N(0,\sigma)$
- The 1:5 rule is applied to change the σ parameter adaptively

Facial Expression Generation



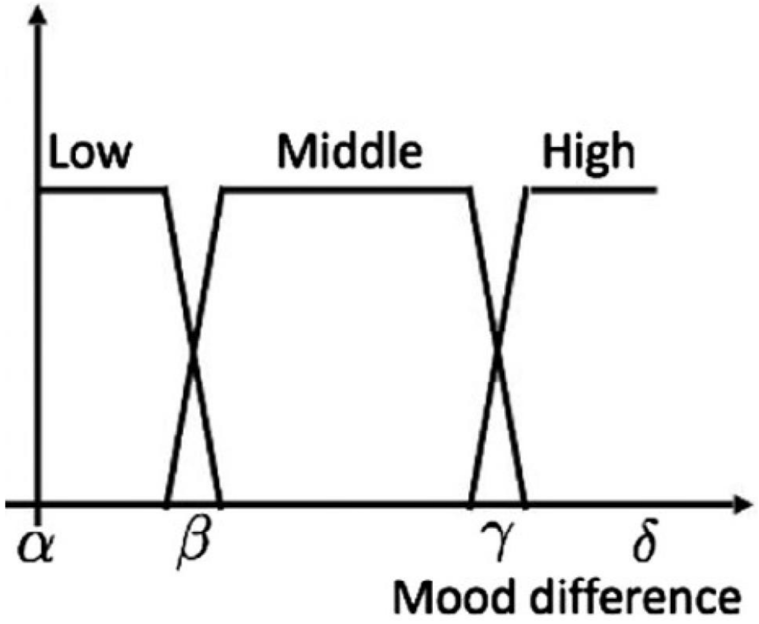
The examples of
Happy faces

Experimental Results



iPhonoid’s Facial Expression

- **IF** Mood difference is LOW **THEN** HAPPY facial expression
- **IF** Mood difference is MIDDLE **THEN** HAPPIER facial expression
- **IF** Mood difference is HIGH **THEN** HAPPIEST facial expression

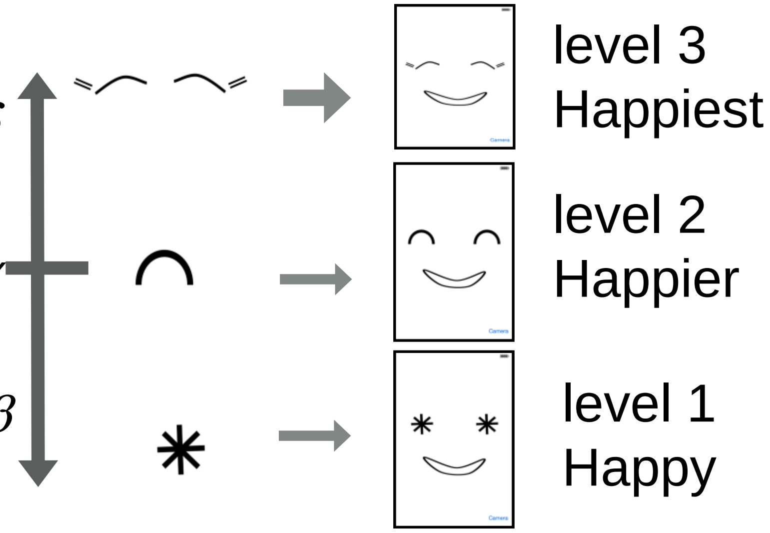


Expression strength

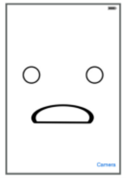
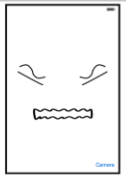
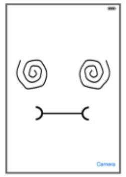
$\gamma < positivemood - negativemood \leq \delta$

$\beta < positivemood - negativemood \leq \gamma$

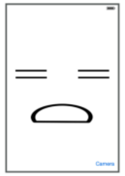
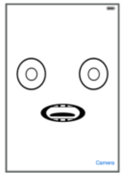
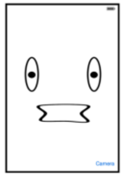
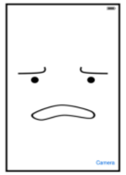
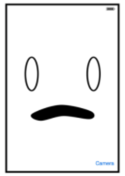
$\alpha \leq positivemood - negativemood \leq \beta$



iPhonoid’s Facial Expression

Emotional parameter	level 1	level 2	level 3
Happy			
Surprise			
Angry			
Disgust			

iPhonoid’s Facial Expression

Emotional parameter	level 1	level 2	level 3
Sad			
Frighten			
Fearful			
Thrill			

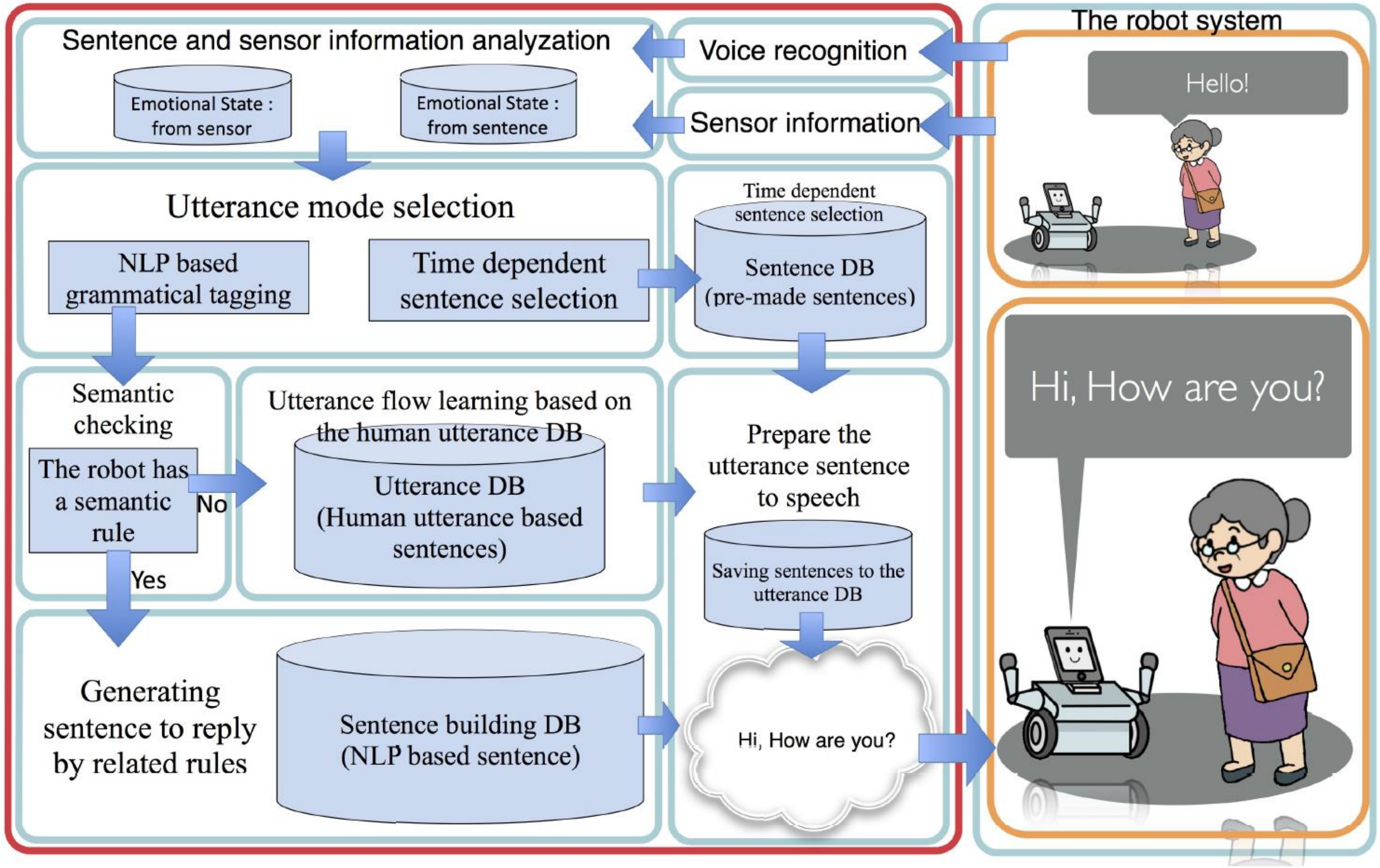
Experimental results

Experimental results

Experimental results

Verbal communication module

Verbal communication system



Human Sentence Input for Emotional Model

Adjective Words Related to Emotional Parameter

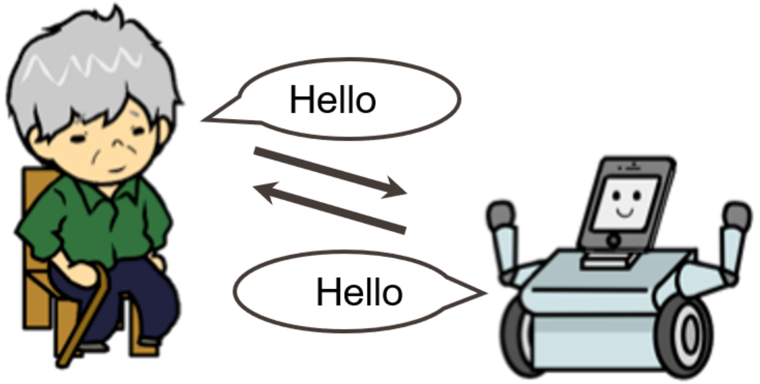
Feelings	Adjective words
Neutral	-
Happy	nice, glad, great, good, pleased
Surprise	wonder, awe, amazing, curiosity, astonished
Angry	enraged, heated, furious, uptight, bad
Disgusting	nasty, hateful, fulsome, shocking, awful
Sad	heartbroken, sorry, wistful, bitter, sick
Frightened	anxious, panicky, spooked, startled, unnerved
Fearful	afraid, hesitant, nervous, scared, tense
Thrilling	frantic, sensational, rousing, miraculous, breathtaking

Communication System for Interaction

- In the communication with people,

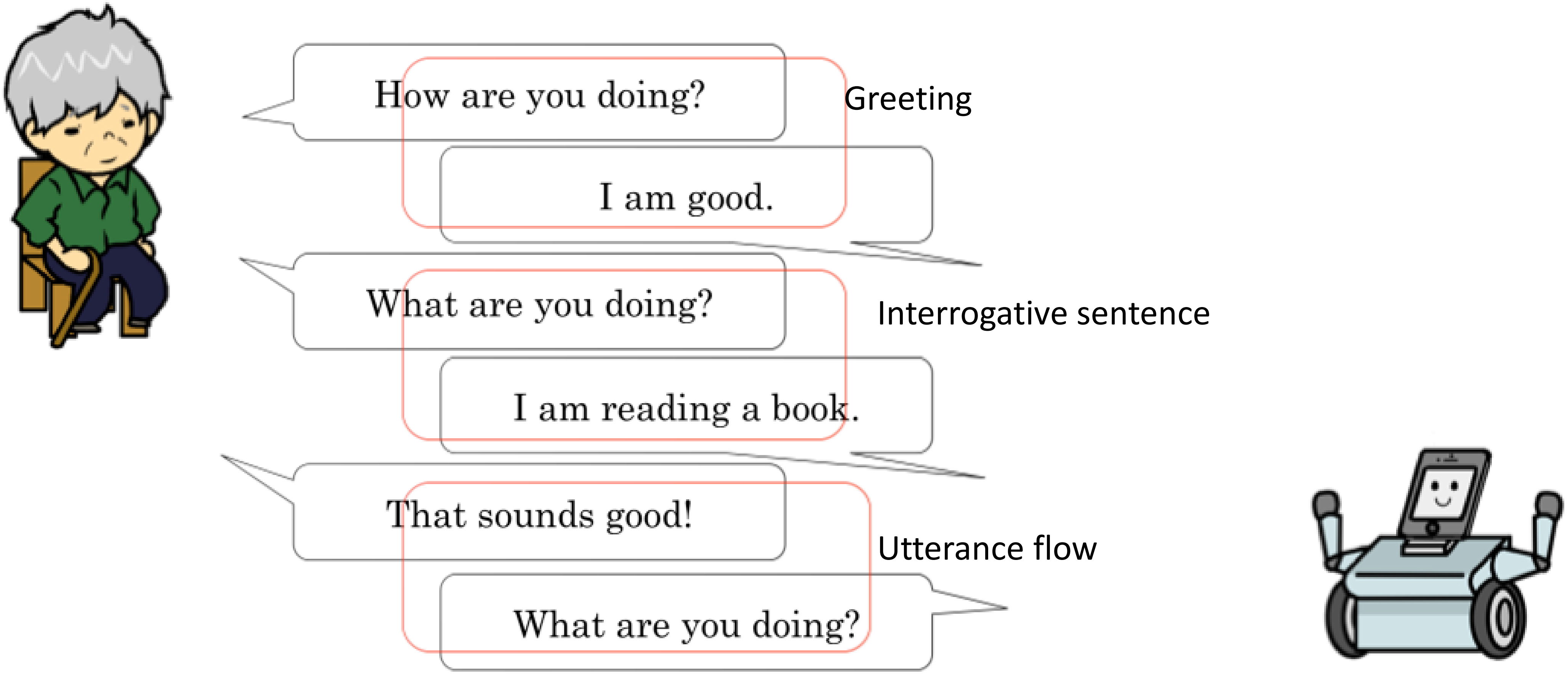
- (1) the number of utterance contents is not enough,
- (2) it is difficult to select suitable utterance sentences,
- (3) basic conversation flow is predefined,

and others....



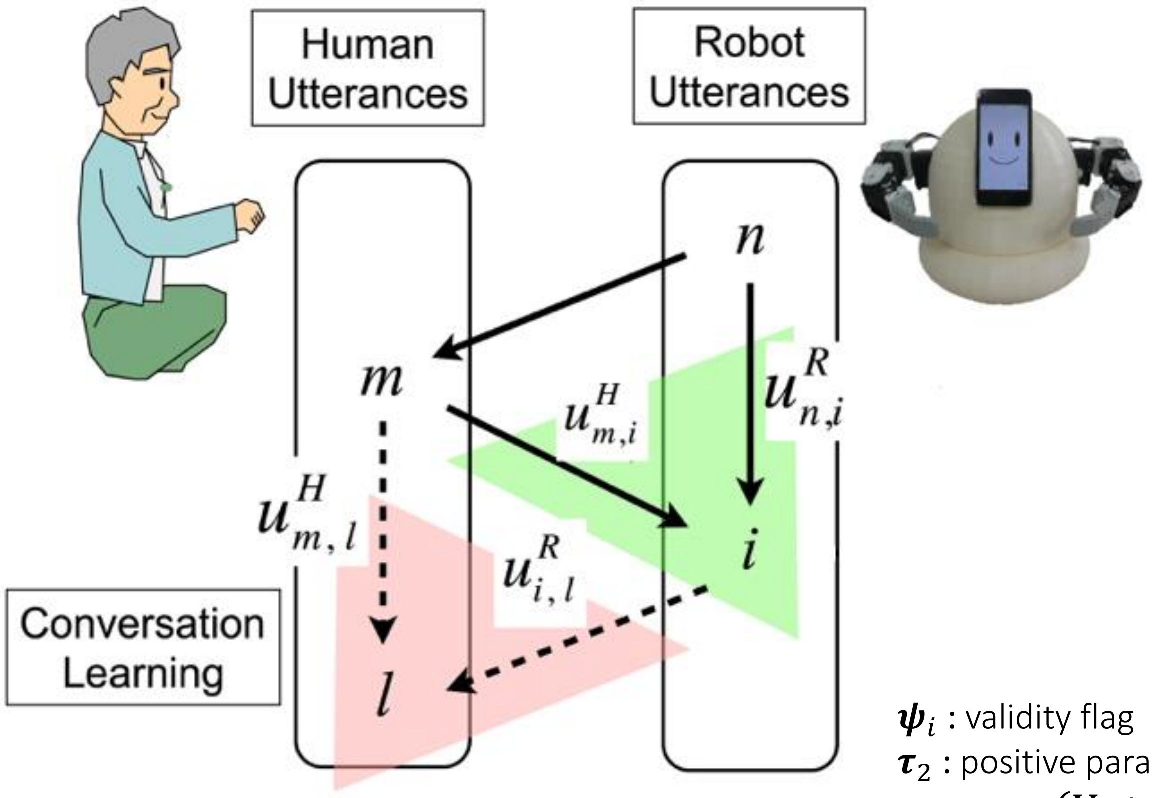
We propose
(1) Utterance learning system based on human conversation
(2) Sentence building based on predefined rules
(3) Time-based utterance system

Conversation Example



Utterance Flow Learning

A conversation flow between a human and a robot partner



$$s_i = u^H_{m,i} + \tau_1 \cdot u^R_{n,i}$$

$u^H_{m,i}$: selection strength of the *i*-th word after the person speaks the *m*-th word

$u^R_{n,i}$: selection strength of the *i*-th word after the robot speaks the *n*-th word

τ_1 : coefficient

$$u^R_{i,l} = \exp\left(\frac{o^R_{i,l}}{o_l + 1}\right) \quad u^H_{m,l} = exp\left(\frac{o^H_{m,l}}{o_l + 1}\right)$$

$o^R_{i,l}$: utterance times of the *l*-th sentence after the robot speaks the *i*-th sentence

$o^H_{m,l}$ utterance times of the *l*-th sentence after the person speaks the *m*-th sentence

o_l : total utterance times of the *l*-th sentence

ψ_i : validity flag

τ_2 : positive parameter

$c_i = \exp(V_i + A_i)$

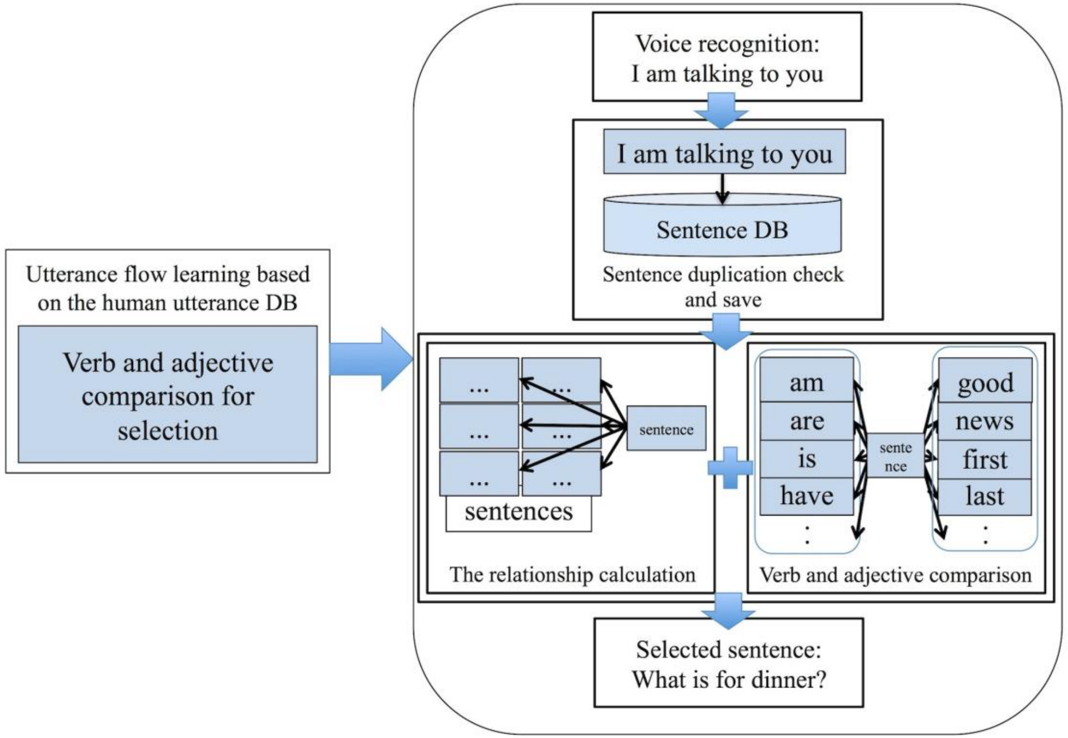
$$M_i^{sentence} = \begin{cases} 1 & if\ M_i^+ - M_i^- > 0 \\ -1 & if\ M_i^+ - M_i^- < 0 \end{cases}$$

$$M_i = M_i^{sentence} \cdot S_i^{mood}$$

$$\boxed{\begin{gathered} v_i = M_i \cdot \frac{c_i \cdot \psi_i \cdot \exp\left(\frac{s_i}{\tau_2}\right)}{\sum_{j=1}^{J} c_j \cdot \psi_j \cdot exp\left(\frac{s_j}{\tau_2}\right)} \\ I = \arg\max_i v_i \end{gathered}}$$

Utterance Flow Learning

	1	2	3	4	5	6	7	8	9	10
Verb	am	are	is	have	do	say	get	make	go	know
Adjective	good	news	first	last	long	great	little	own	other	old



Parameter Setting for Relationship : Verb

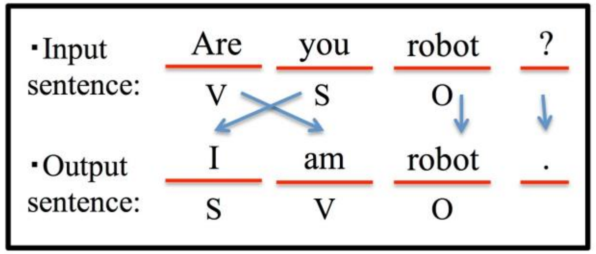
	am	are	is	have	do	say	get	make	go	know
am	0.1	0.8	0.5	0.4	0.4	0.5	0.5	0.5	0.6	0.6
are	0.8	0.1	0.2	0.5	0.5	0.5	0.7	0.6	0.6	0.6
is	0.5	0.2	0.1	0.5	0.4	0.3	0.6	0.6	0.4	0.4
have	0.4	0.5	0.5	0.1	0.6	0.4	0.3	0.4	0.3	0.4
do	0.4	0.5	0.4	0.6	0.1	0.3	0.4	0.5	0.5	0.4
say	0.5	0.5	0.3	0.4	0.3	0.1	0.4	0.4	0.3	0.5
get	0.5	0.7	0.6	0.3	0.4	0.4	0.1	0.5	0.4	0.4
make	0.5	0.6	0.6	0.4	0.5	0.4	0.5	0.1	0.4	0.4
go	0.6	0.6	0.4	0.3	0.5	0.3	0.4	0.4	0.1	0.5
know	0.6	0.6	0.4	0.4	0.4	0.5	0.4	0.4	0.5	0.1

Parameter Setting for Relationship : Adjective

	good	news	first	last	long	great	little	own	other	old
good	0.1	0.8	0.4	0.4	0.6	0.7	0.6	0.5	0.4	0.5
news	0.8	0.1	0.6	0.5	0.6	0.6	0.4	0.4	0.6	0.4
first	0.4	0.6	0.1	0.5	0.4	0.4	0.3	0.5	0.4	0.4
last	0.4	0.5	0.5	0.1	0.4	0.4	0.3	0.4	0.4	0.6
long	0.6	0.6	0.4	0.4	0.1	0.6	0.2	0.4	0.5	0.5
great	0.7	0.6	0.4	0.4	0.6	0.1	0.2	0.6	0.4	0.6
little	0.6	0.4	0.3	0.3	0.2	0.2	0.1	0.4	0.5	0.4
own	0.5	0.4	0.5	0.4	0.4	0.6	0.4	0.1	0.5	0.6
other	0.4	0.6	0.4	0.4	0.5	0.4	0.5	0.5	0.1	0.5
old	0.5	0.4	0.4	0.6	0.5	0.6	0.4	0.6	0.5	0.1

Sentence Building

- The robot can make a sentence based on the grammar rule and predefined personal information



(Subject conversion)	from	to
1	you	I
2	I	you
3	robot	robot
4	your	my
5	my	your
6	me	you
…	…	…

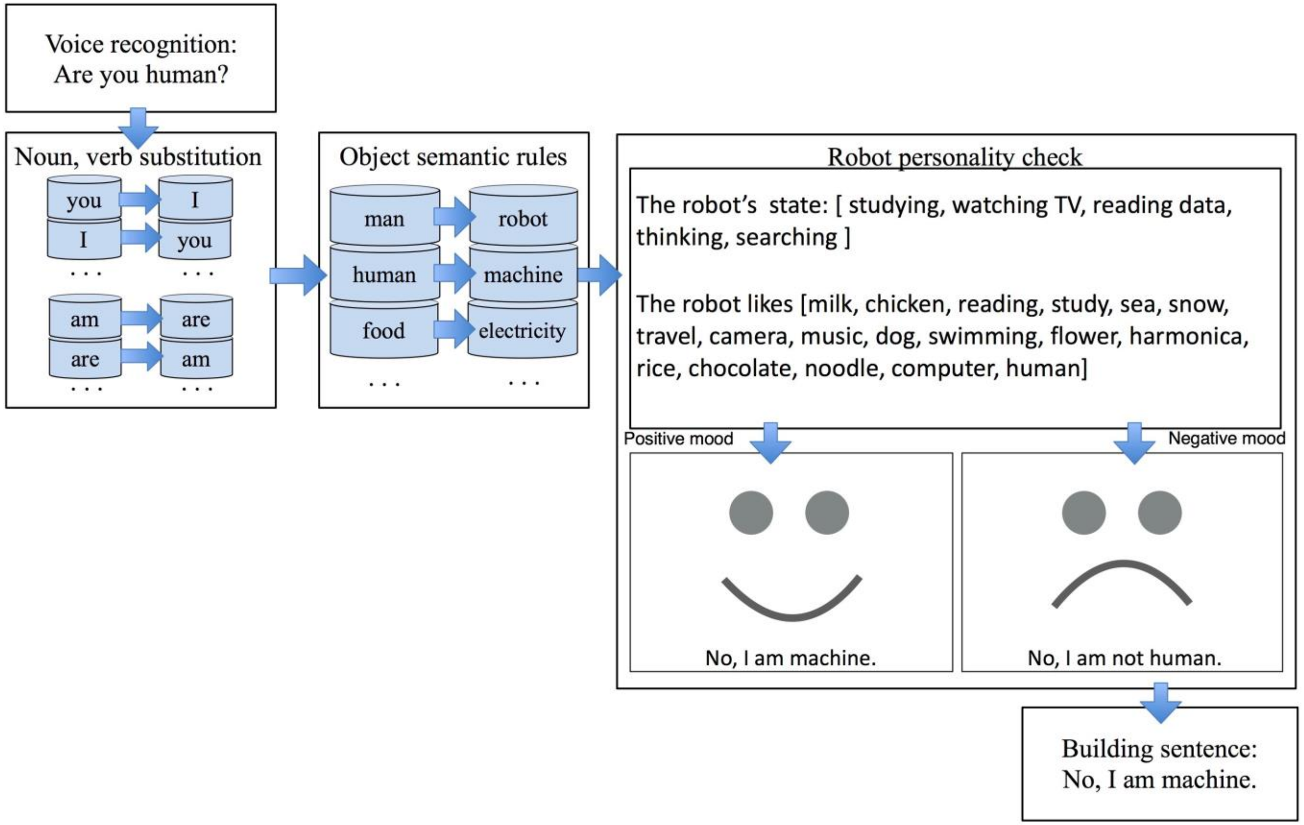
(Verb conversion)	from	to
1	am	are
2	are	am
3	was	were
4	were	was
5	…	…

(Objective conversion)	from	to
1	man	robot
2	woman	
3	boy	
4	girl	
5	human	machine
6	soul	algorithm
7	gender	neutral
8	food	electricity
…	…	…

An example of the sentence building rule

Sentence Building

The robot can make a sentence based on the grammar rule and predefined personal information

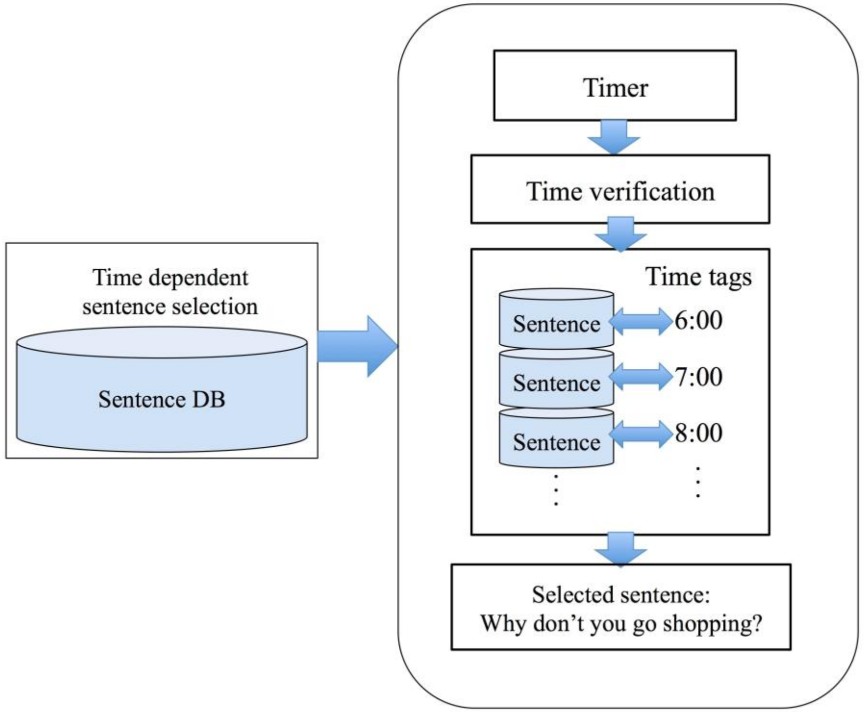


$$M_i = M_i^{sentence} \cdot S_i^{mood}$$

$$M_i^{sentence} = \begin{cases} 1 & if\ M_i^+ - M_i^- > 0 \\ -1 & if\ M_i^+ - M_i^- < 0 \end{cases}$$

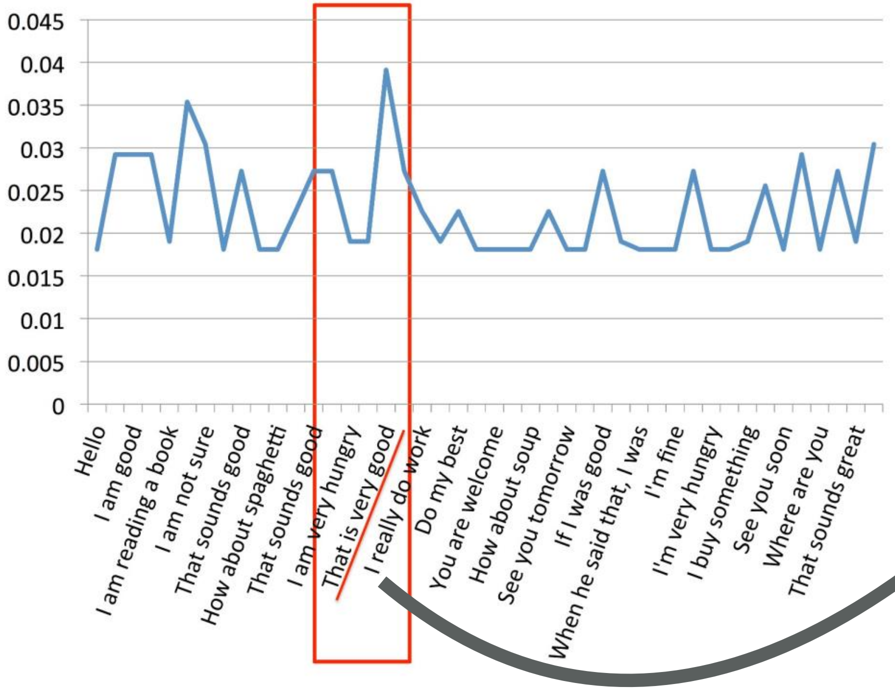
Time Dependent Utterance

- The robot performs utterance by using predefined sentence
- For example: schedule, news, encouragement of going out



The time-based utterance selection module

Experimental Results



Utterance result graph

$$I = \arg\max_i v_i$$

	human	robot
1	Hello.	How are you?
2	I'm good, thank you.	I am good.
3	That sounds great.	What are you doing?
4	I am thinking some ideas.	That is very good.
5	What are you doing?	I am studying.
6	Are you human?	No, I am machine.
7	I see.	What are you doing?
8	I am working now.	I am working now.
9	Do you like sports?	No, I don't like sports.
10	I see, I like swim.	Do you like sports?
11	Yes, I like swim.	Yes, I like swim.

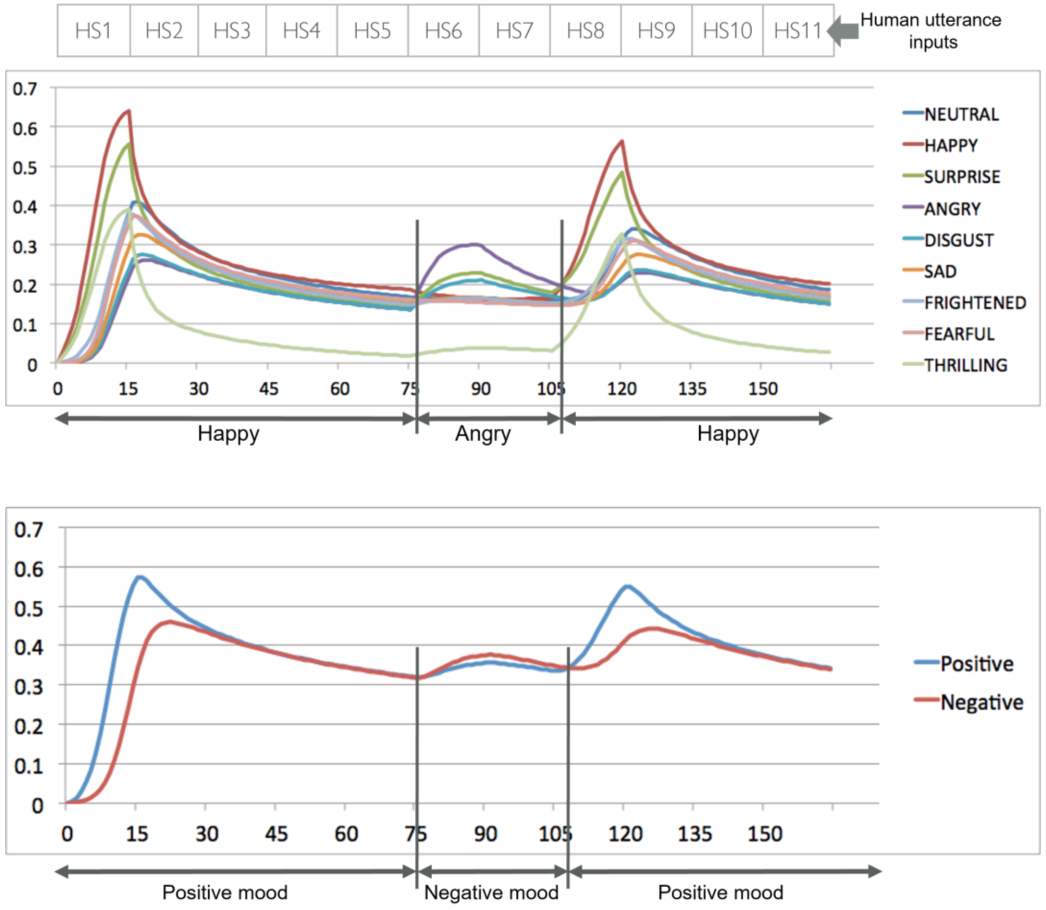
: Utterance flow learning

: Sentence building

Experimental Results

- Robot: Hello.
- User: Hello.
- Robot : How are you?
- User: I am good, Thank you.
- Robot: I am good.
- User: That sounds great.
- Robot: What are you doing.
- User: I am thinking some ideas.
- Robot: Yes.
- User: What are you doing?
- Robot: I am searching.
- User: Are you human.
- Robot: No, I am machine.
- User: I see.
- Robot: I am not sure.
- User: Do you like sports.
- Robot: No, I don’t like sports.
- User: I see, I like swim.

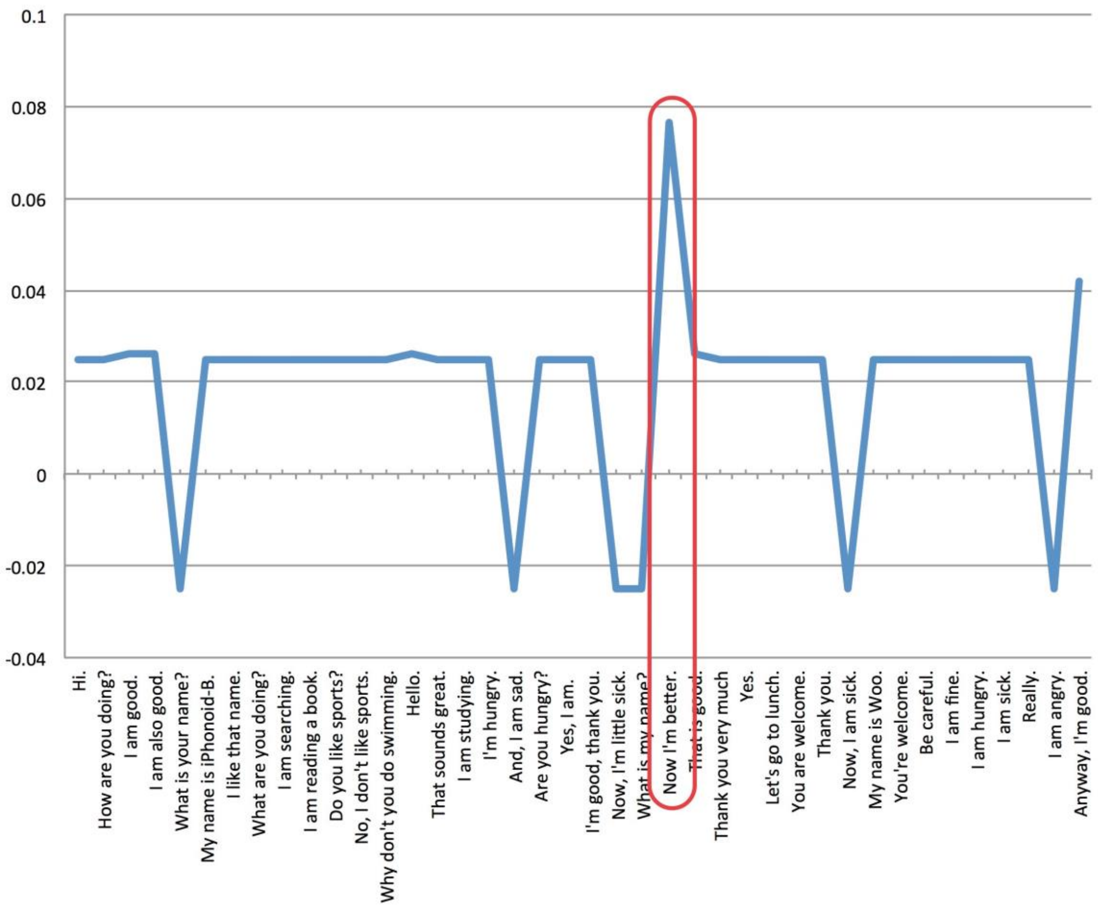
Experimental Results



Experimental Results

	Human	Robot	Mode
HS1	Hello.	I'm good, thank you.	CFUS, Happy(1)
HS2	You are good.	You are welcome.	CFUS Neutral(1)
HS3	How are you doing?	I am good.	SBUS, Happy(1)
HS4	I am sick.	That is good.	CFUS Happy(1)
HS5	Really?	Really.	CFUS, Happy(1)
HS6	I am angry.	I am angry.	CFUS, Angry(-1)
HS7	What is your name?	What is my name?	SBUS, Angry(-1)
HS8	Anyway, I'm good.	Now, I'm better.	CFUS, Happy(1)
HS9	What is your name?	My name is iPhonoid-B.	SBUS, Happy(1)
HS10	Okay, thank you.	I like that name.	SBUS, Happy(1)
HS11	Me too.	Okay, thank you.	CFUS, Happy(1)

Experimental Results



$$\boldsymbol{v_i} = \boldsymbol{M_i} \cdot \frac{\boldsymbol{c_i \cdot \psi_i \cdot \exp\left(\frac{s_i}{\tau_2}\right)}}{\boldsymbol{\sum_{j=1}^{J} c_j \cdot \psi_j \cdot exp\left(\frac{s_j}{\tau_2}\right)}}$$

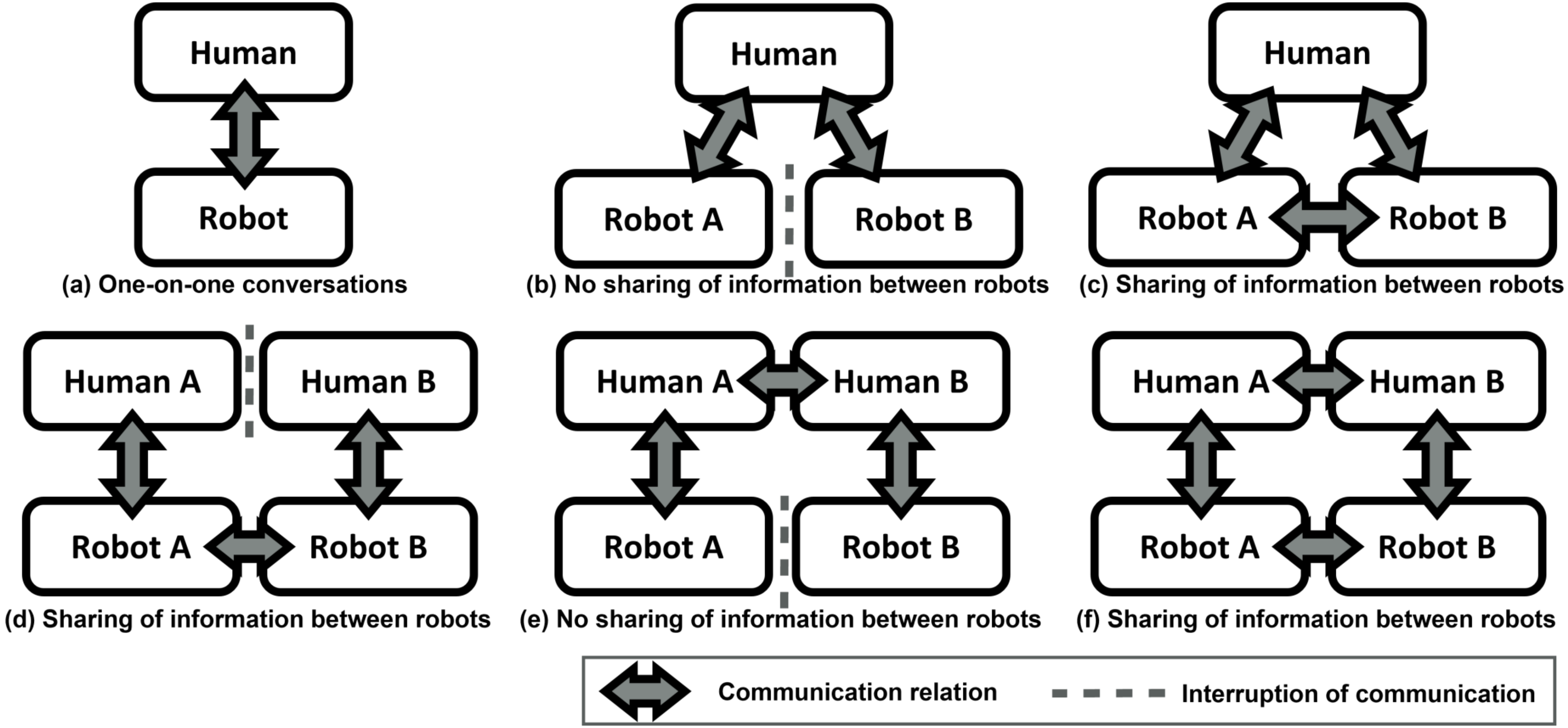
$$M_i = M_i^{sentence} \cdot S_i^{mood}$$

$$M_i^{sentence} = \begin{cases} 1 & if\ M_i^+ - M_i^- > 0 \\ -1 & if\ M_i^+ - M_i^- < 0 \end{cases}$$

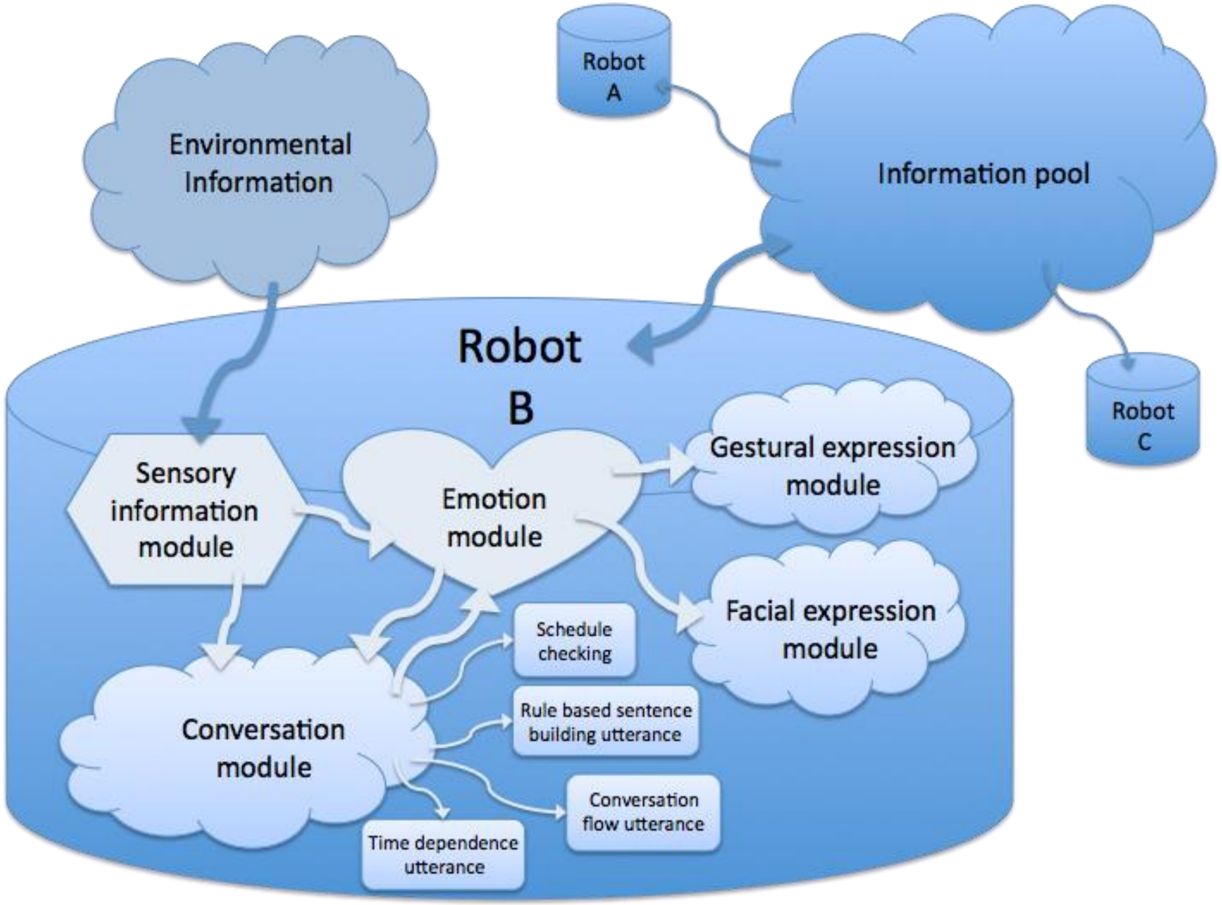
Experimental results

	Human	Robot	Mode
HS1	How are you doing?	I am good.	SBUS, Happy(1)
HS2	I am sick.	Really.	CFUS, Happy(1)
HS3	So, I am angry.	So, I am angry.	**CFUS, Angry(-1)**
HS4	What is your name?	What is my name?	SBUS, Angry(-1)
HS5	Please, take it easy!	Please, take it easy!	**CFUS, Angry(-1)**
HS6	Now, I am little happy!	Now, I am little happy!	**CFUS, Happy(1)**
HS7	What is your name?	My name is iPhonoid-C.	SBUS, Happy(1)
HS8	Okay, Thank you so much.	What is your name?	CFUS, Happy(1)
HS9	My name is Woo.	My name is Woo.	**CFUS, Happy(1)**
HS10	Please remember me!	If you remember me.	CFUS, Happy(1)
HS11	I will remember!	Bye bye.	CFUS, Happy(1)
HS12	Bye.	Bye bye.	CFUS, Happy(1)

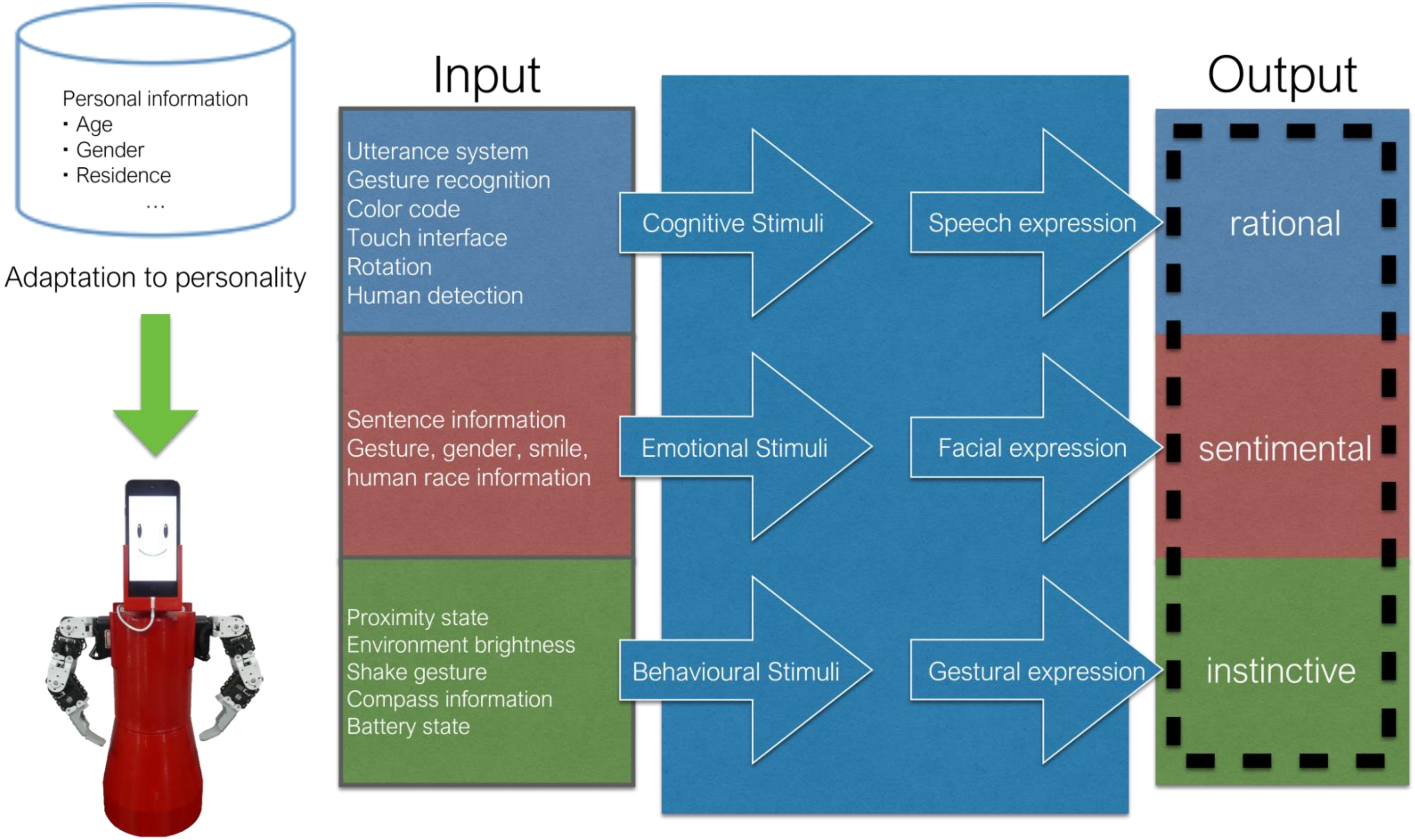
Multiple Robots



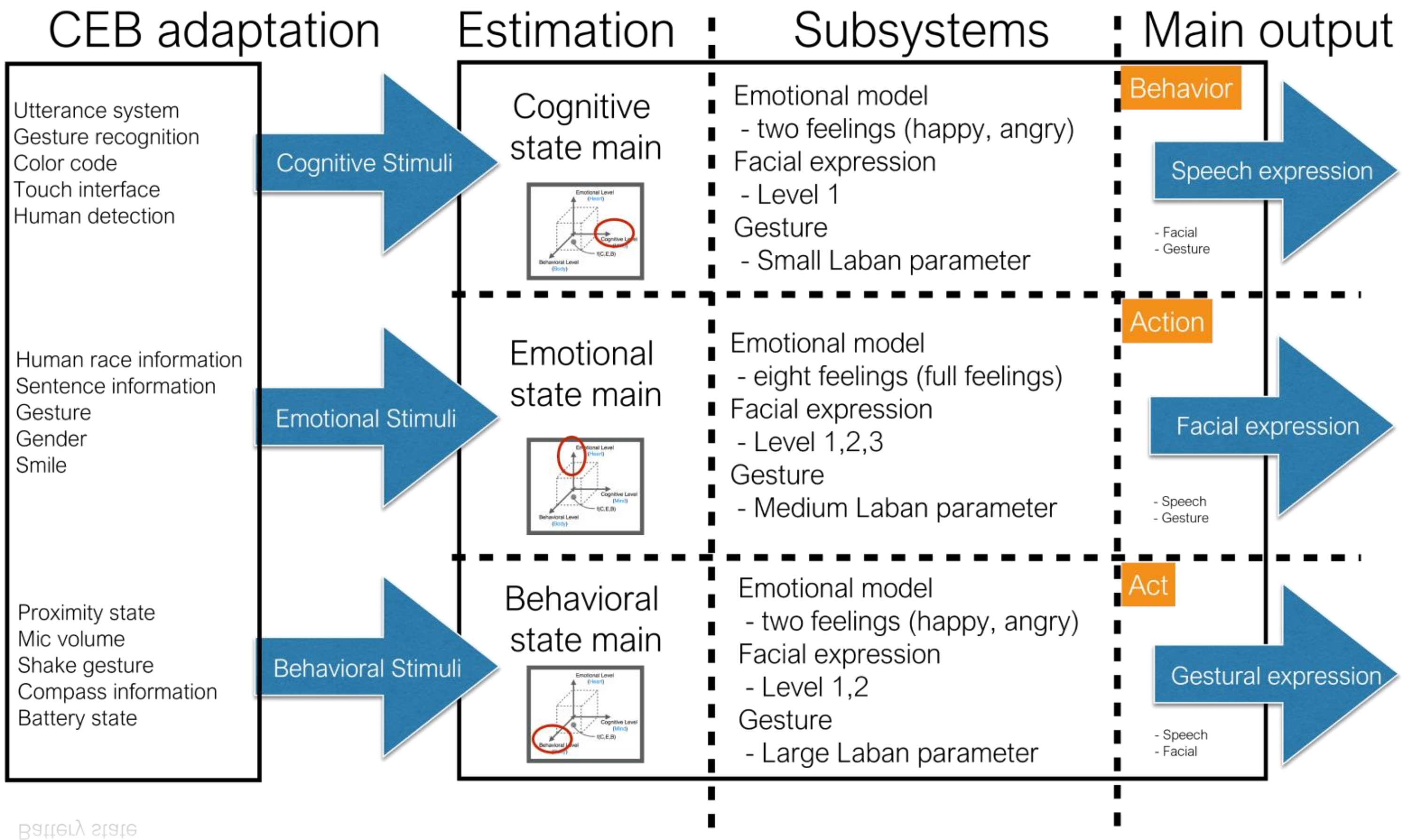
Multiple robots



Another Cognitive Model of iPhonoid



Another Cognitive Model of iPhonoid



Sensory Information

Input Information	Parameters (Every 0.5 seconds)						Value
Human gesture	hand up down	0	left right	1	circling	2	0 or 1
Image color	skin color	3	red color	4	blue color	6	0 or 1
Display touch	tap	long press	up	down	left	right	0 or 1
Finger radius	20 - 100						0.0 - 1.0
Human detection	nobody	0		human	1		0 or 1
Human distance	1.5m - 0.1m						0.0 - 1.0
Human gesture	hand up down	0		left right	1		0 or 1
Smile	no smile	0		smiling	1		0 or 1
Gender	woman	1		man	2		0 or 1
Racial	non asian	0		asian	1		0 or 1
Proximity sensor	nothing	0		covered	1		0 or 1
Mic volume	-120 - 0						0 or 1
Body shake	no shaking	0		shaking	1		0 or 1
Compass direction	north	0.0	west and east	0.5	south	1.0	0.0 - 1.0
Battery status	Battery level						0.0 - 1.0
Step counter	-						-

Sensory Information

Input Information	Parameters (Every 0.5 seconds)	Value
Human gesture	Hand up down, left right, circling	0 or 1
Image color	Skin, red, blue	0 or 1
Display touch	Tap, long press, up, down, left, right	0 or 1
Touched finger radius	20 - 100	0.0 - 1.0
Human detection	Human or nobody	0 or 1
Human distance	1.5m - 0.1m	0.0 - 1.0
Human gesture	Hand up down, left right, circling	0 or 1
Smile	Smiling or not	0 or 1
Gender	Woman or Man	0 or 1
Racial	Asian or Non asian	0 or 1
Proximity sensor	Nothing or covered	0 or 1
Mic volume	-120 = 0	0.0 - 1.0
Body shake	Shaking or not	0 or 1
Compass direction	North to South	0.0 - 1.0
Battery status	Battery level	0.0 - 1.0
Step counter	-	-