

인간-로봇 사회적 상호작용을 위한 핵심 기술

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Korea **Institute** of Science
and **Technology**

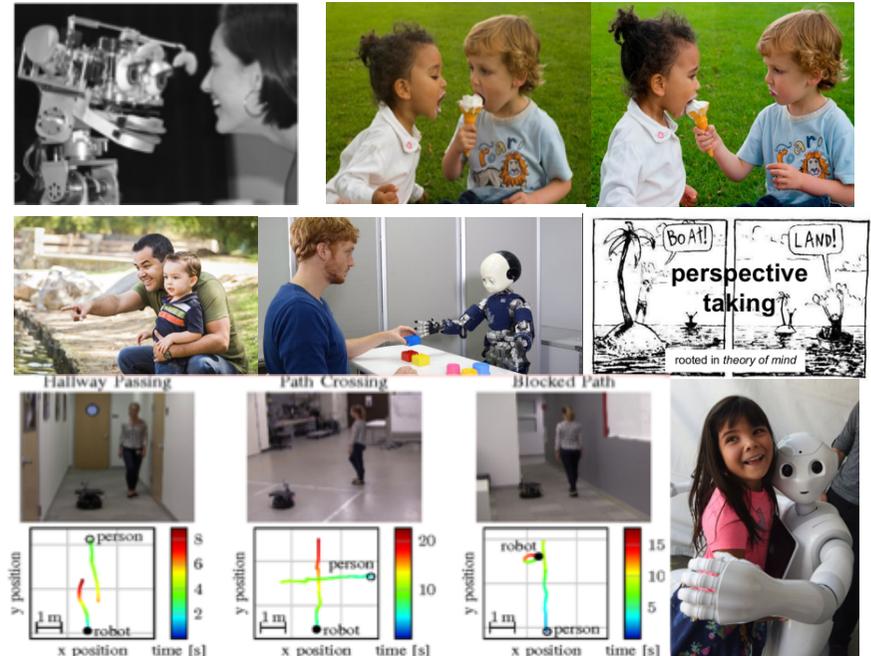
한국과학기술연구원

What is sHRI?

What is sHRI?

Human-Robot Interaction in **the socially acceptable way** such as

- ✓ Eye contact
- ✓ Turn-taking by intention reading
- ✓ Joint attention
- ✓ Perspective-taking
- ✓ Social navigation behaviors
- ✓ Cooperative planning
- ✓ Proactive behaviors to learn task semantics from demonstration
- ✓ Emotional empathy or sympathy
- ✓ ...



Social (Robot) Intelligence is the key technology for sHRI



Social Robot Intelligence

Motivation

Strong Assumption !

- Human always approach the robot with their attention
- They are all newcomers to the place
- Human don't stop paying attention to the robot until the robot stops its expression.
- ...



What If ?

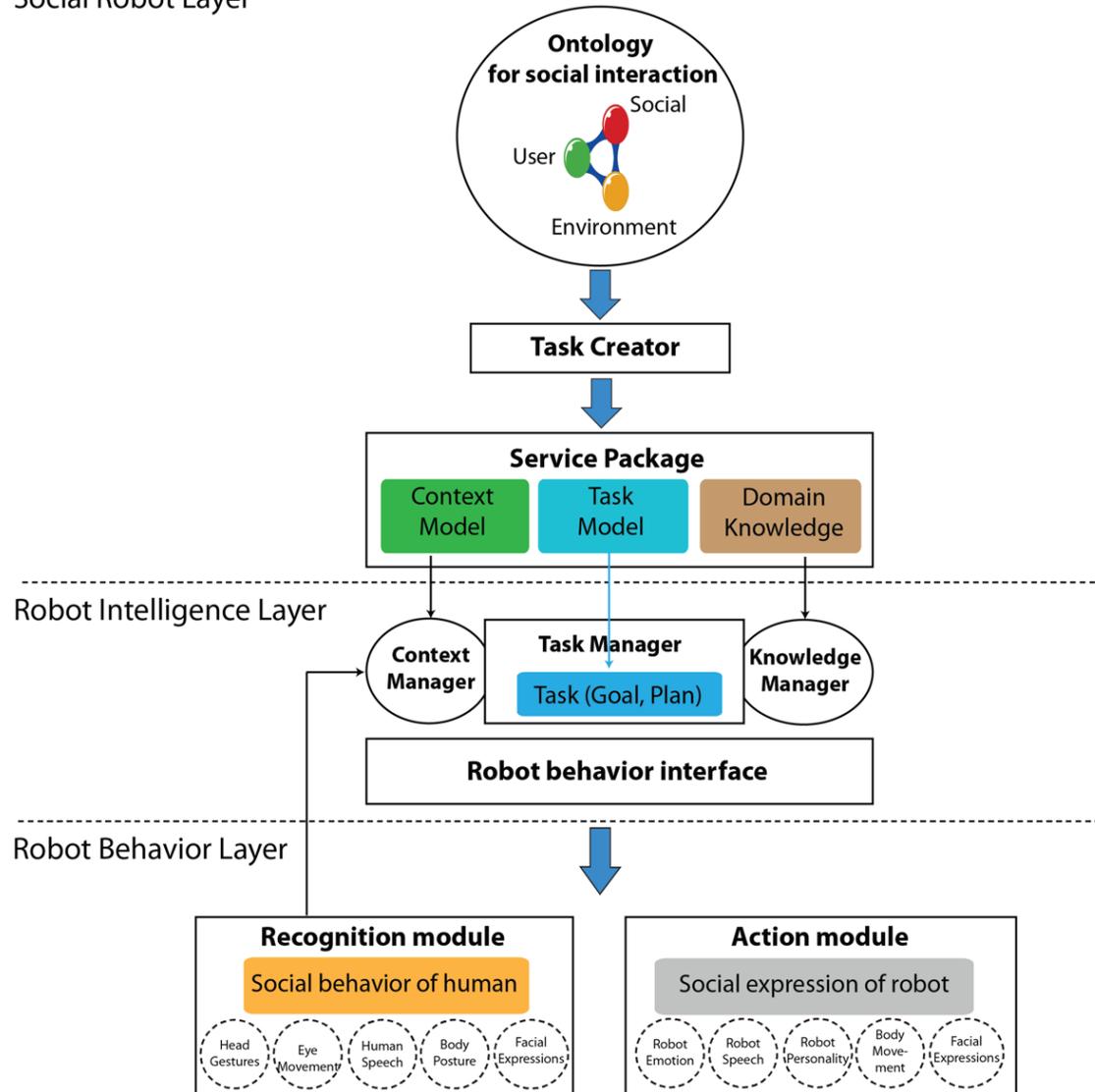
- If someone is just passing by w/o attention?
- If someone is already familiar with the place?
- If someone feels bored and then wants to leave?
- If the person is not a customer but a clerk?
- If we change the robot?
- ...

Social Intelligence !

Proposed System (from a sHRI-related project *DeepTask*)

“Development of Social Robot Intelligence for sHRI of Service Robots”

Social Robot Layer



Approaches

1. Social behavior recognition

(Electronics and Telecommunication Research Institute, Korea Institute of Science and Technology)

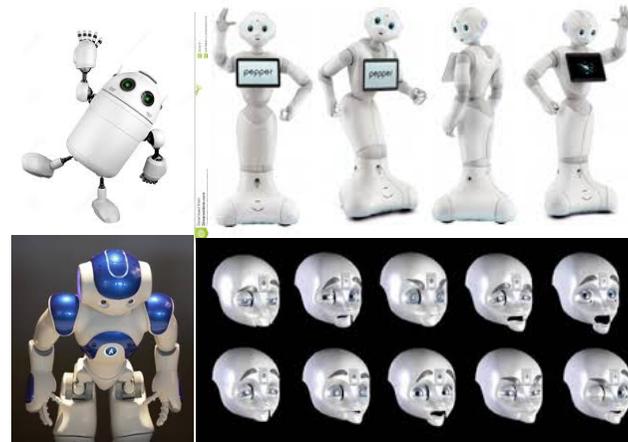
- Deep learning based social behavior perception
- Human-Human and Human-robot interaction data acquisition
- Long term human behavior tracking technology
- Social dialogue act model for Korean language



2. Social expression and behavior of robot

(University of Auckland)

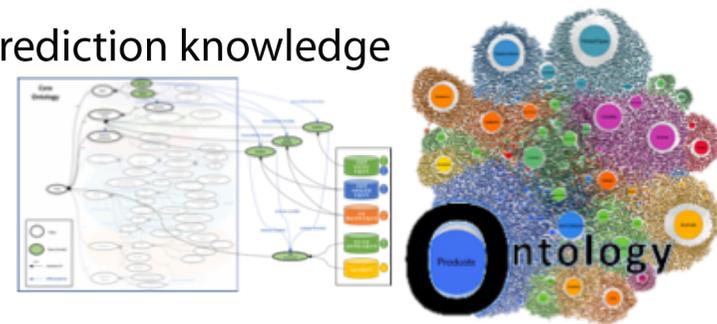
- Robot personality model based on human behavior
- Emotion and speech expression model
- Robot speech and movement coordination



3. Social task knowledge

(Hanyang University and University of Seoul)

- BDI (Belief-Desire-Intention) based user intention prediction knowledge
- Social interaction ontology
- External web data based knowledge expansion



4. User evaluation

(Ewha Womans University)

- Social interaction model evaluation
- Social cue based interaction model

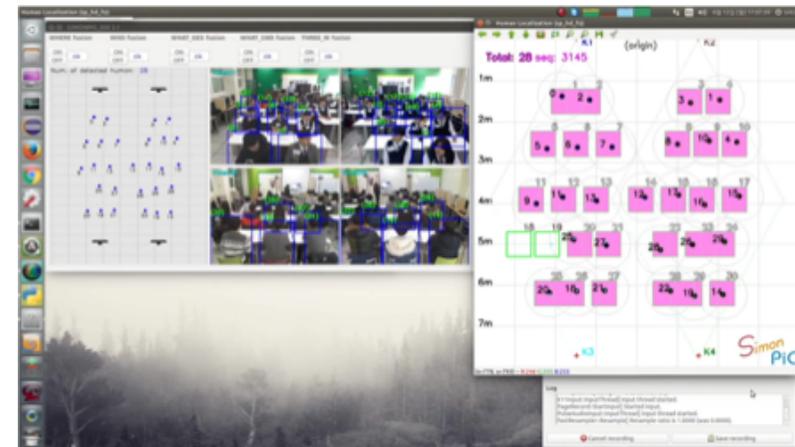
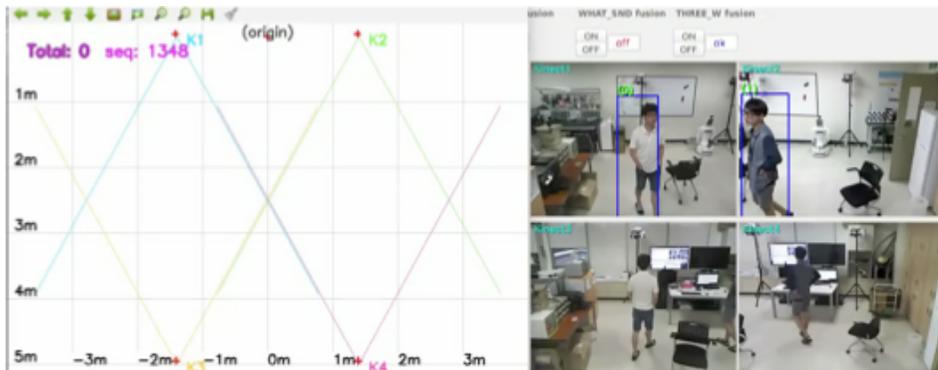
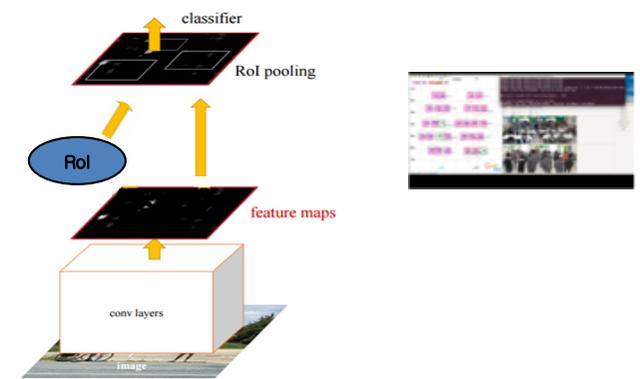
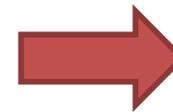
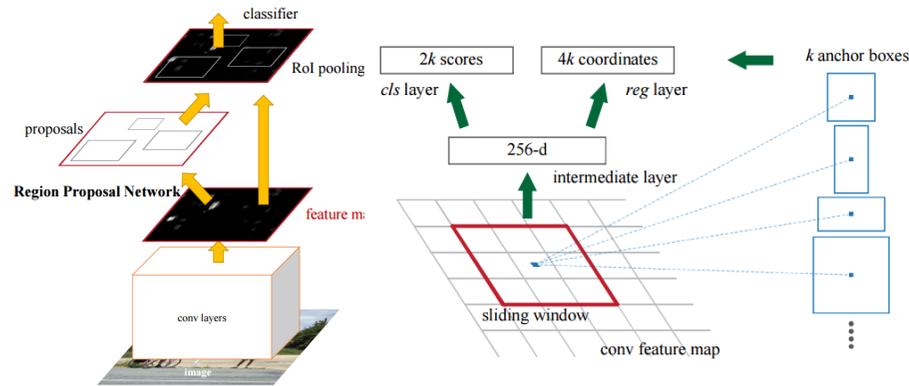


[Perception]

WHERE (사람의 위치 추적)

- Modified **faster R-CNN**

- 기존의 ROI를 **Modified faster R-CNN** (zf)에 활용 → **비휴먼**(로봇, 문, 책상, 의자 등) **검출제거**
- 30명 인원 에 대한 사용자 출입, 검출실패, 가려짐 등에 강인한 다중 객체 추적



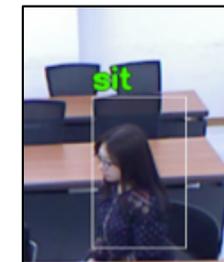
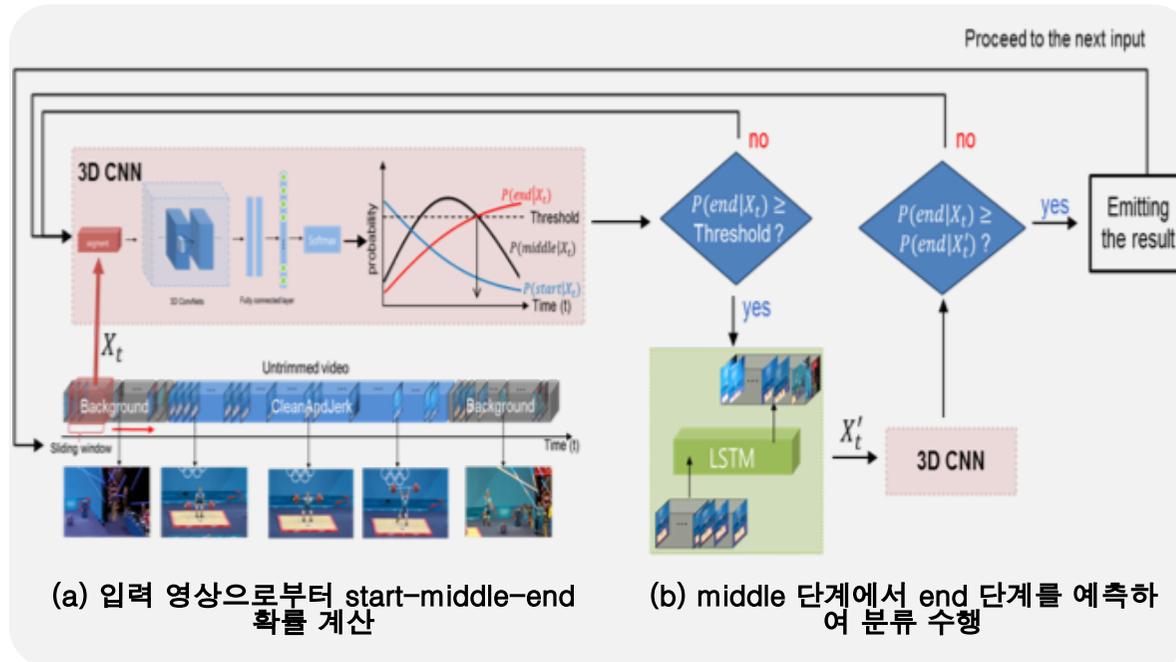
WHAT (사람의 행위 인식)

▶ 제스처 및 행동 인식 프레임워크 개선

- 딥러닝(LSTM) 기반 행동 길이 변화 대응 가능 행동 인식 수행 → 연속적인 행동 인식 프레임워크 개발

- 행동을 "start-middle-end" 단계로 구분지어서 인식
- 3D CNN 구조를 이용하여 각 단계를 학습
- 입력 정보가 불충분한 상태에서의 강인한 행동 인식을 위해 현재의 판단을 기반으로 앞으로의 입력을 예측 수행

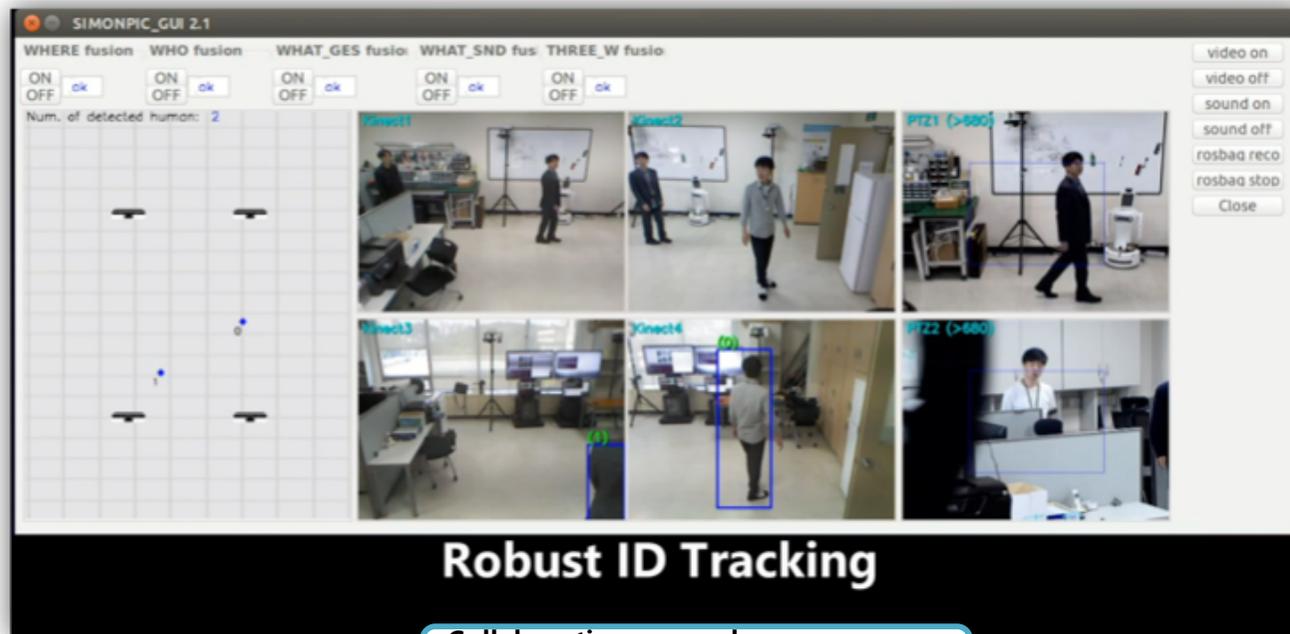
➔ LSTM (Long Short Term Memory) 구조를 이용하여 "end" 단계 생성을 통해 분류 성능 개선



딥러닝 기반 연속적인 행동 인식 프레임워크개념도

Collaborative research:
KIST & KU, 2017

Results: 3W [WHERE + WHO + WHAT (A/V)]

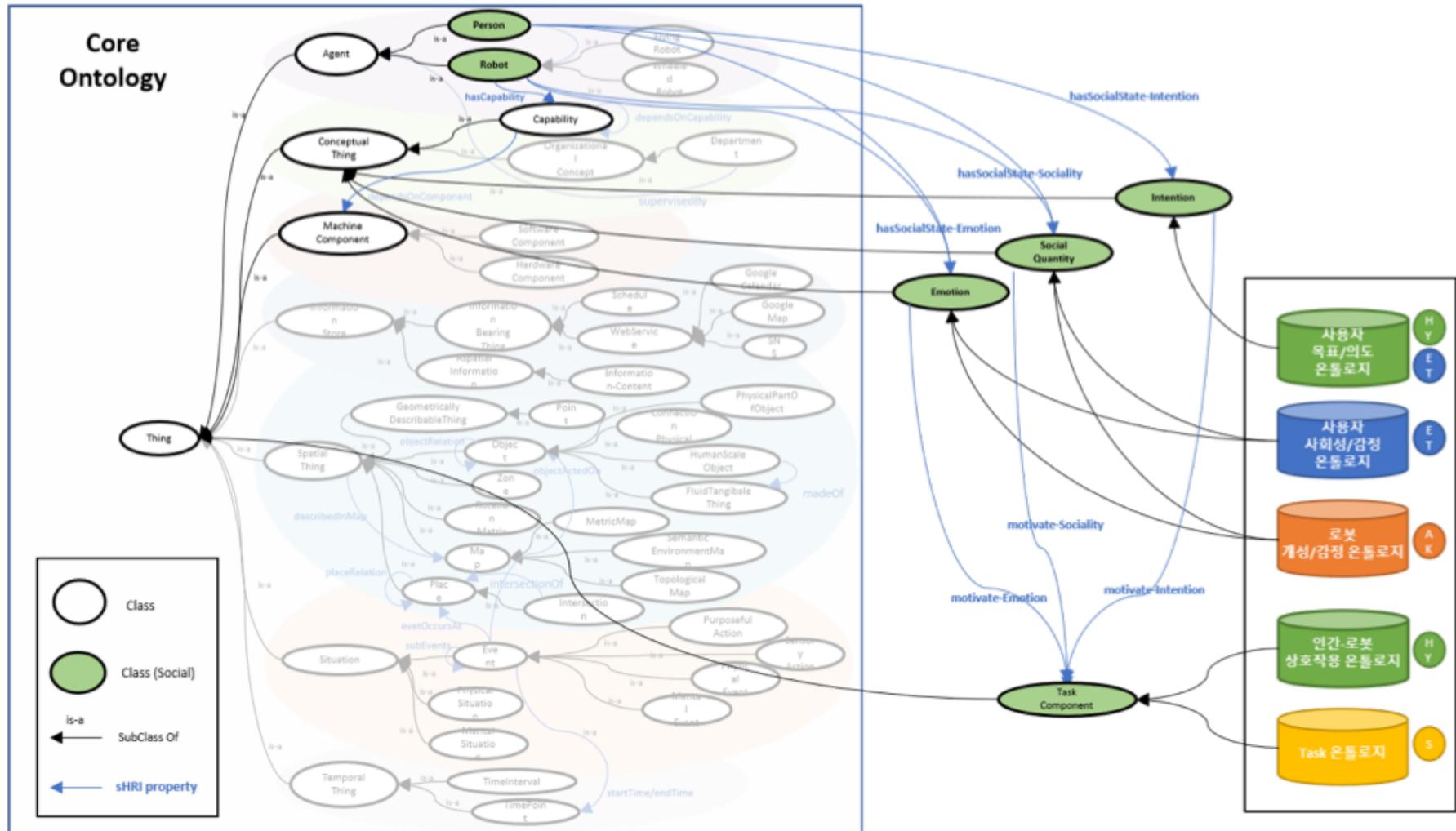


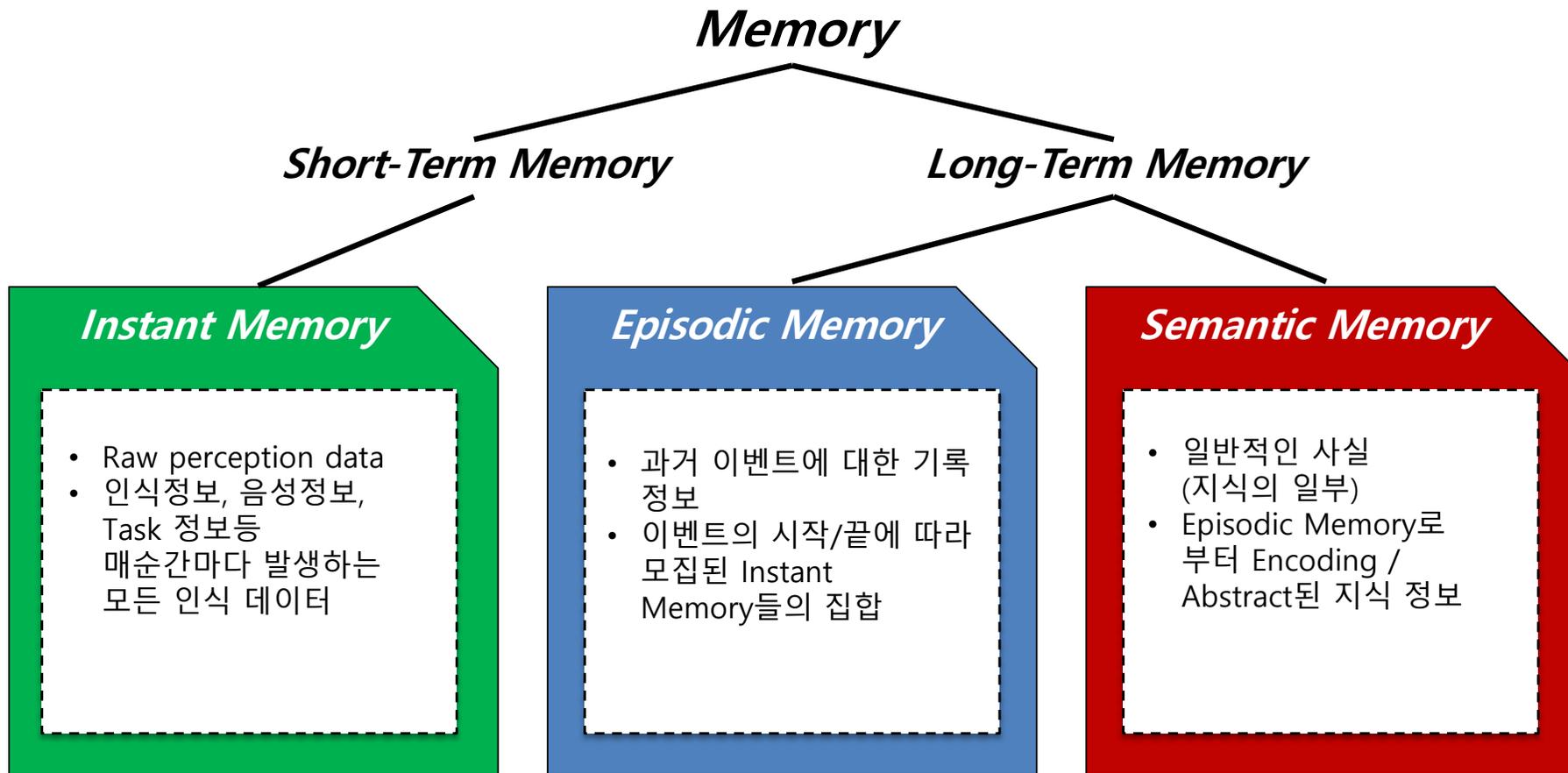
Collaborative research:
KIST, POSTECH & KU, 2017



[Cognition]

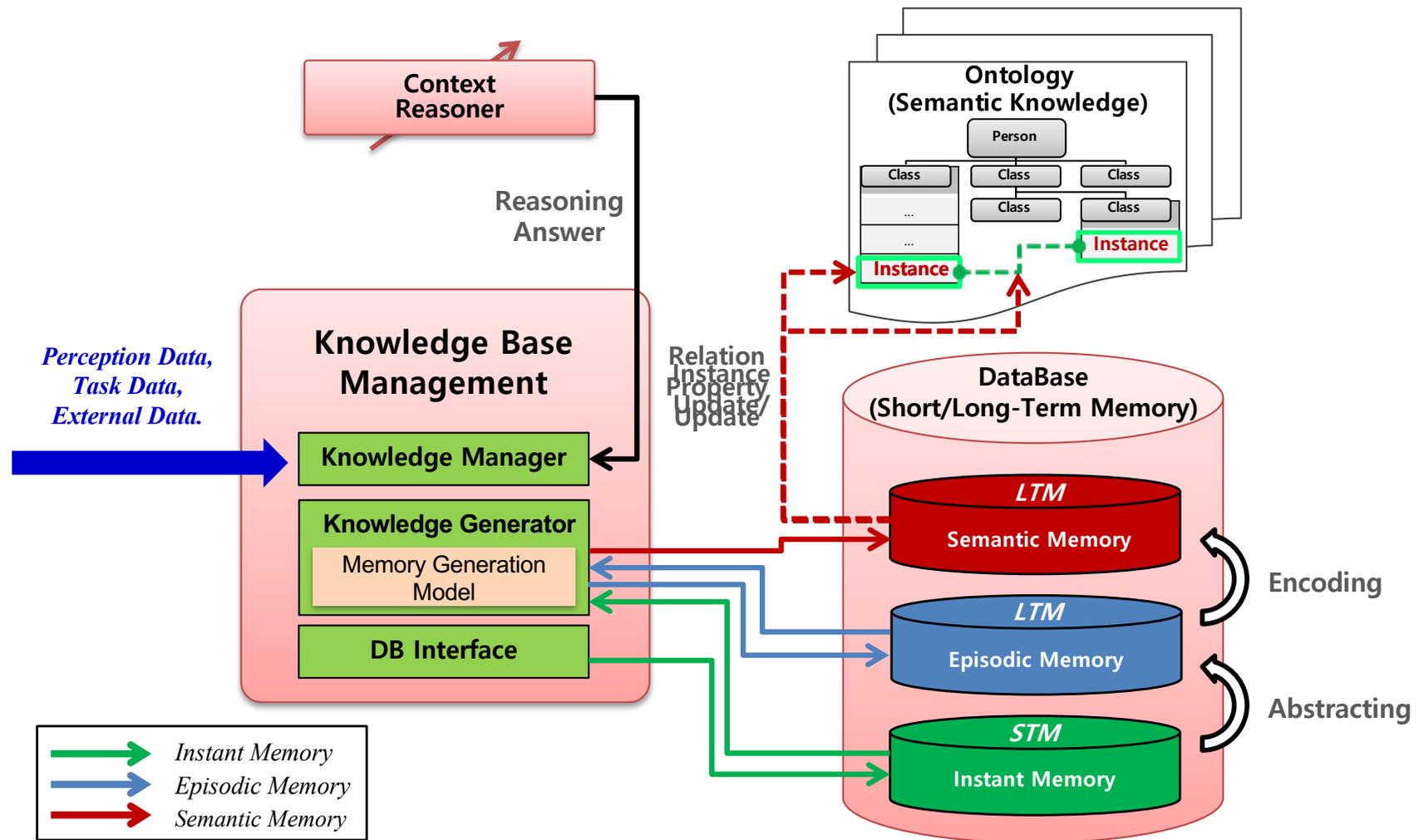
Knowledge (Ontology)





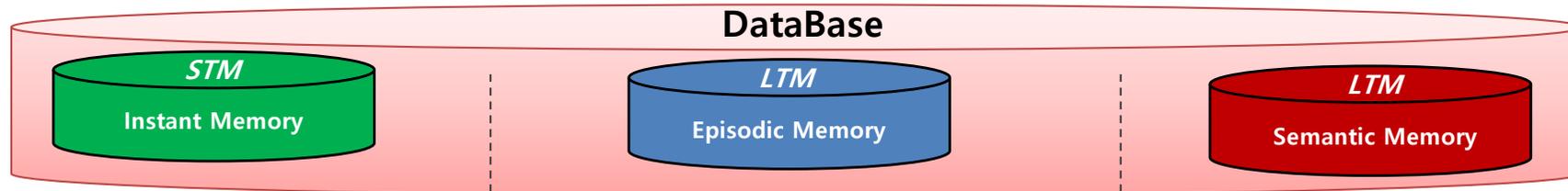
Knowledge Base Management

Memory Generation Process



Knowledge Base Management

Knowledge(Personality) Generation in Memory System



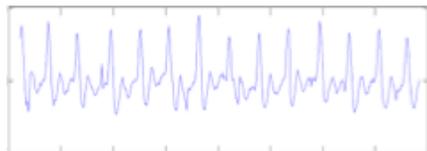
Thin Slice of Behaviors (Non-Verbal Features Set)



<음성 신호>
(목소리 톤, 음압 변화, 발화 간격)

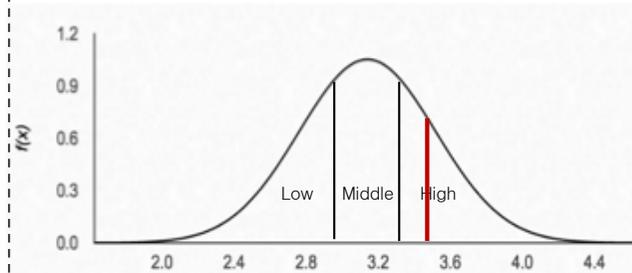


<영상 신호>
(이동거리, 관절 정보)

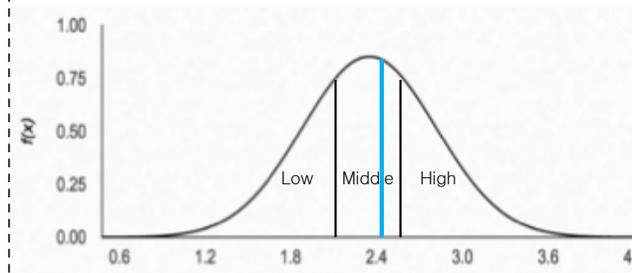


<생체 신호>
(체온, 심박수, 근전도도)

Thin Slice based Personality



외향성(E)



정서불안성(ES)

Long-Term Personality

대표 성격

Category	Subject	Predicate	Object
일반적인	철수(사용자)	의 대표성격은	조금 외향적 신경질적

능력 별 성격

Category	Subject	Predicate	Object
가능한 일	철수(사용자)	의 성격은	외향적 조금 신경질적
불가능한 일	철수(사용자)	의 성격은	조금 외향적 많이 신경질적

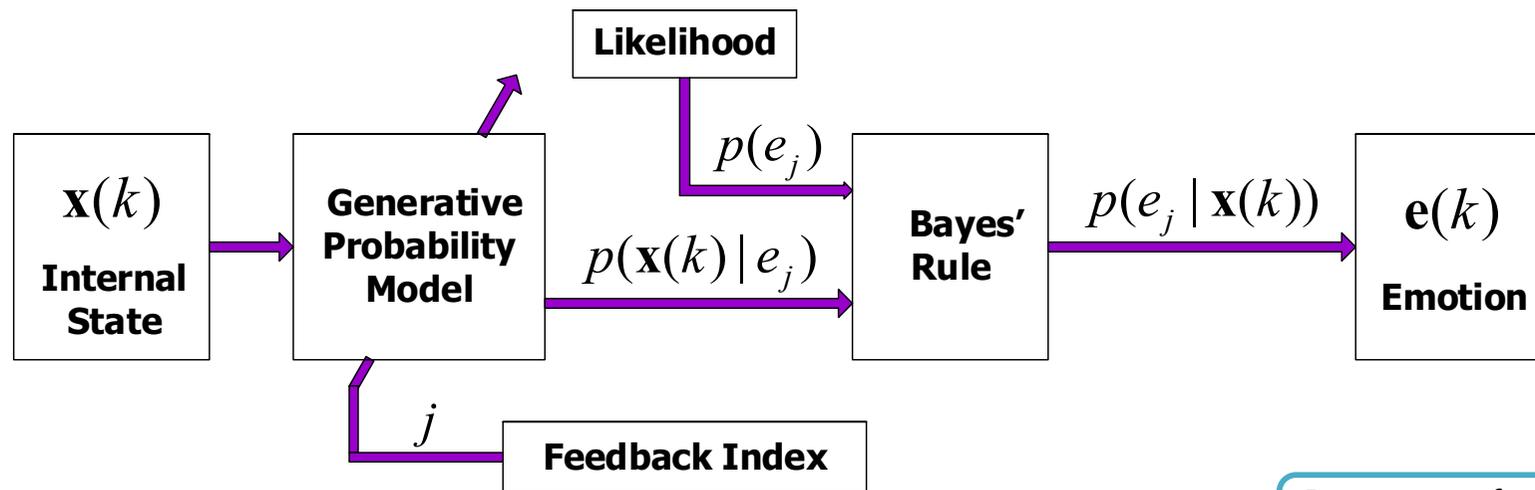
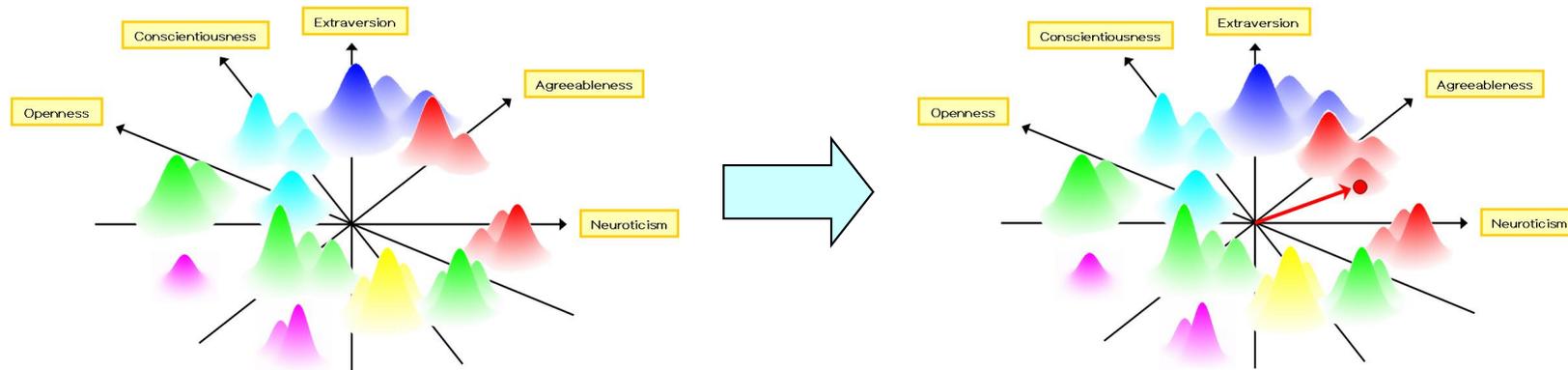
선호 별 성격

Category	Subject	Predicate	Object
좋아하는 일	철수(사용자)	의 성격은	많이 외향적 조금 신경질적
싫어하는 일	철수(사용자)	의 성격은	조금 외향적 신경질적

[Expression]

Robot's characteristics

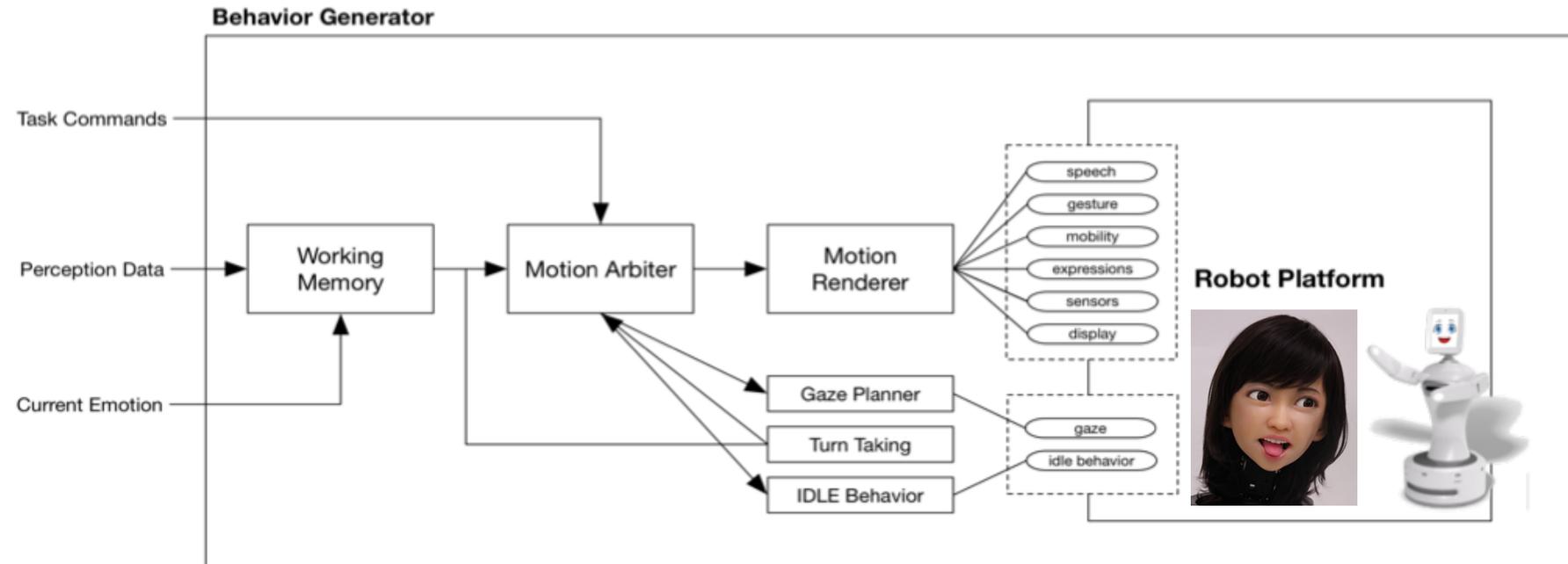
- 5 Factor model + GMM



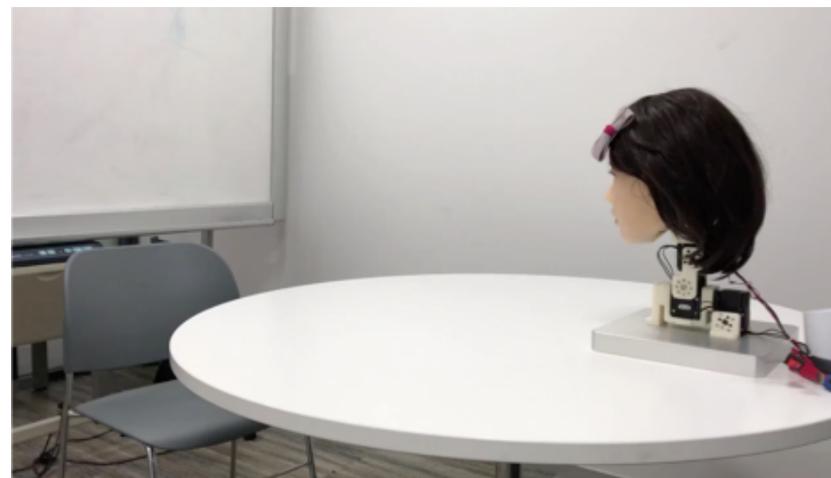
By courtesy of
Prof. Ho Seok Ahn, UoA

Robot's behavior generation

- Platform independent, multi-modal expression



<병원 내 안내 서비스>



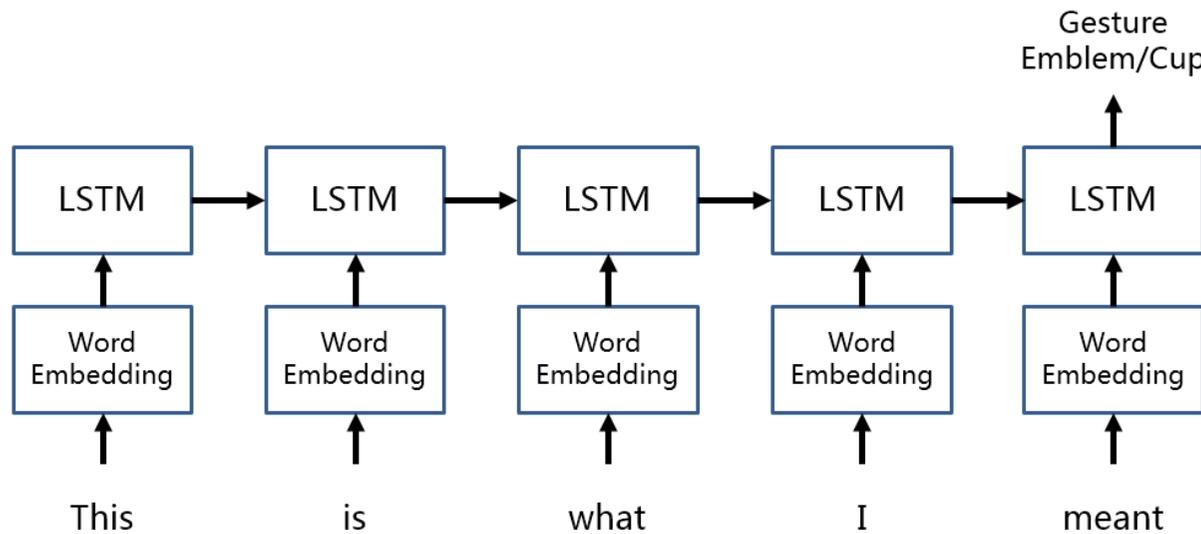
By courtesy of
Prof. Ho Seok Ahn, UoA

Speech-Gesture Behavior

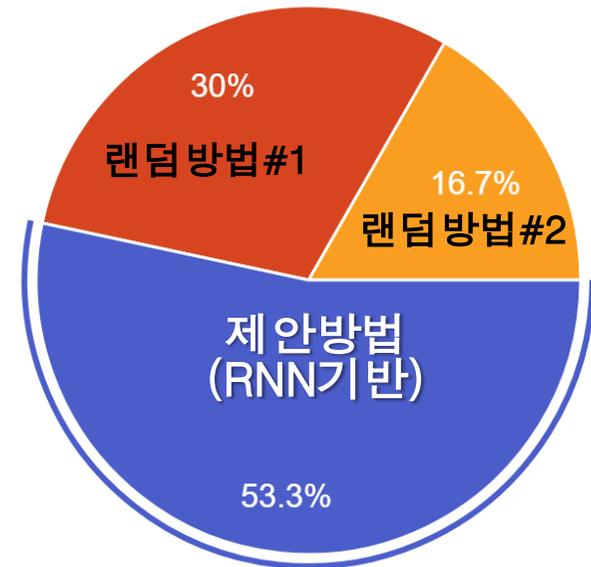
대화 상황에 적절한 로봇 제스처 생성 기술 개발

By courtesy of
Dr. Minsoo Chang, ETRI

- 로봇 제스처 생성 모델 설계 및 구현
 - Recurrent Neural Network 기반 제스처 분류 모델
 - 언어 해석을 위해 Twitter로부터 학습된 Word Embedding 사용
 - 수집된 TED 영상 및 자막으로 Network 학습
 - NAO 로봇에서 발화 문장에 대한 제스처 생성 시스템 개발
 - 31명을 대상으로 한 설문 평가 결과, 학습된 모델을 가장 선호 함 (학습된 모델과 랜덤 선택을 포함한 3개 모델 간 비교)

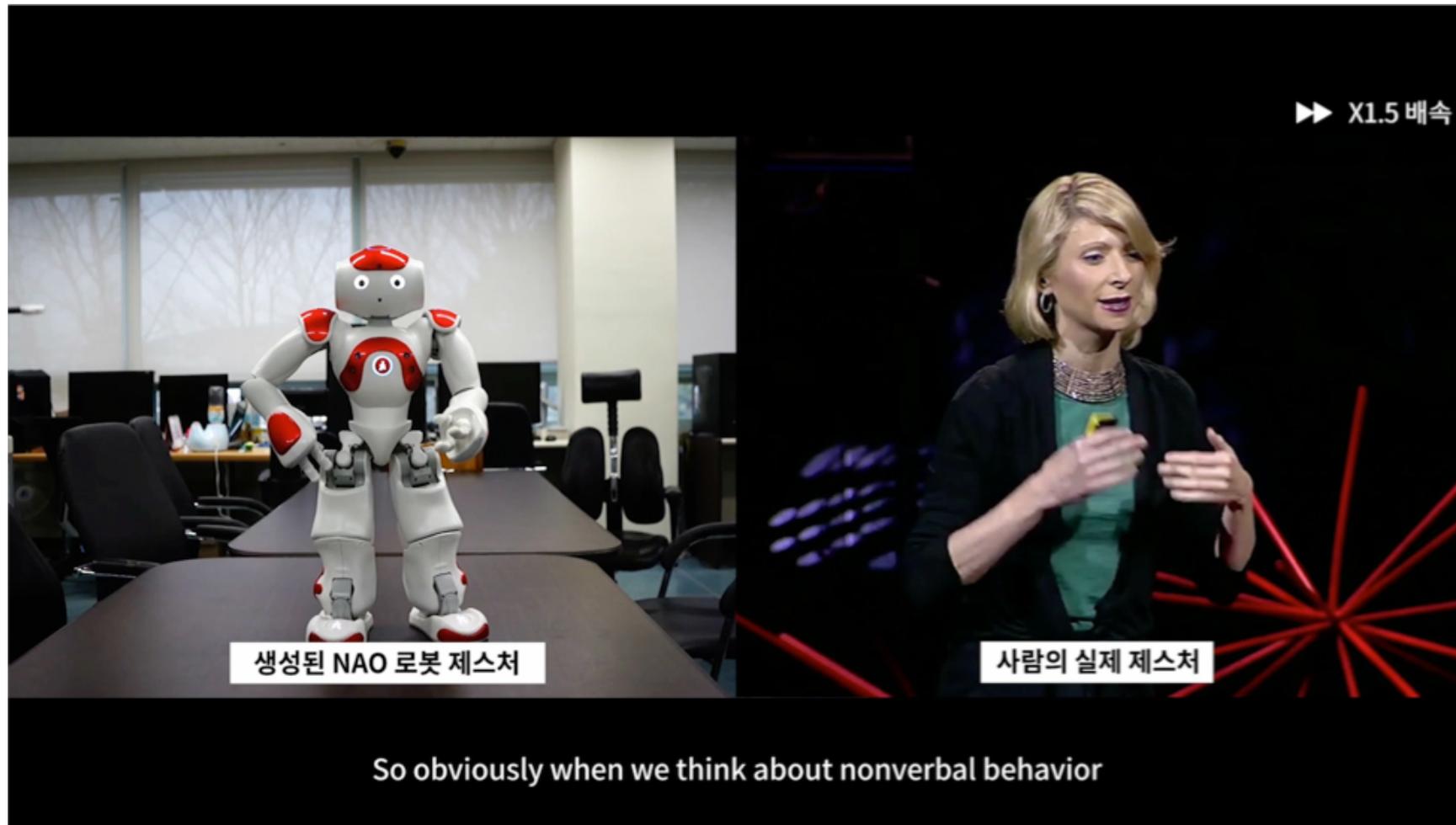


< 제스처 선택 모델 >



< 사용자 대상 평가 결과 (선호도) >

Speech-Gesture Behavior



[Simple Integration]

Social HRI: *Encounter*

Layout

Map

SP-CAM

[사회적 거리에 따른 상호 작용]

사람 행동 : **실내 진입**
(Distance Salutation)

로봇 행동 : **주의 끌기 - 인사**
(Attract Attention)

[대화에 따른 상호작용]

Social Context :
이름 : 이겨레, 성별 : 남성
연령대 : 성인, 방문 기록 : 무

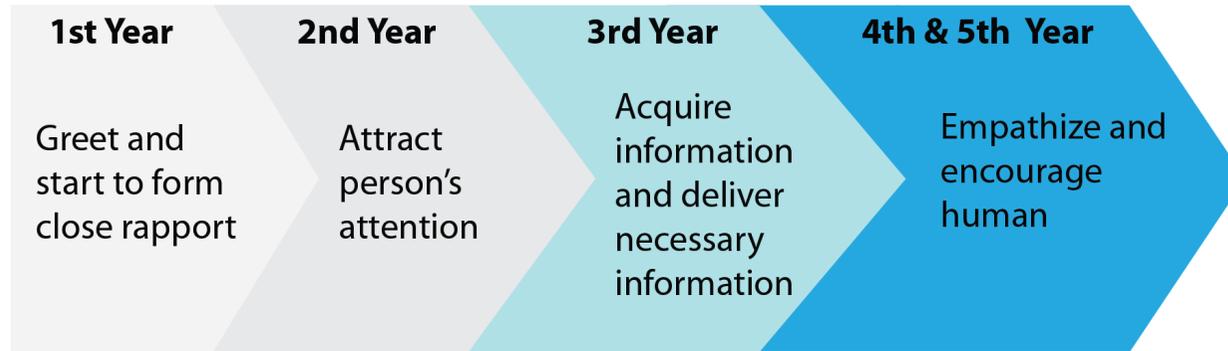
Social Context :
이름 : 최태민, 성별 : 남성
연령대 : 노인, 방문 기록 : 유

제가 무엇을 도와드리면 될까요?

또 오셨네요. 최태민 어르신,
제가 무엇을 도와드리면 될까요?

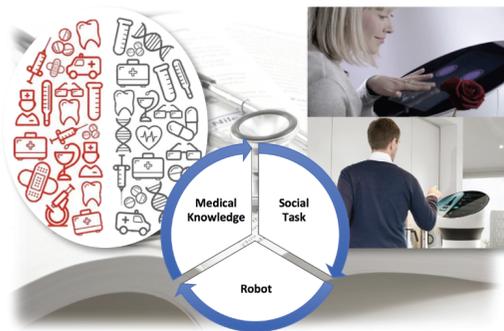
Project plan and applications (from *DeepTask*)

Project Plan



Social interaction applications

Healthcare service



- Deliver basic medical information to elders
- Understand the social relation with users especially with elder people

Reception service



- Reception service for department store, university library, etc

- **sHRI: HRI in the way of social acceptance**

- ✓ Eye contact
- ✓ Turn-taking by intention reading
- ✓ Joint attention
- ✓ Perspective-taking
- ✓ Social navigation behaviors
- ✓ Cooperative planning
- ✓ Proactive behaviors to learn task semantics from demonstration
- ✓ Emotional empathy or sympathy
- ✓ ...

- **sRI (Social Robot Intelligence)** is the key technology for sHRI

- ✓ Perception
- ✓ Cognition
- ✓ Expression

- **sDS (Social Domain Services)** need to be set-up to show the necessity of sRI

- ✓ Healthcare service
- ✓ Reception service
- ✓ ...

- **Multi-disciplinary Research**

- ✓ AI, Robot, Psychology, Human-Factor, UI/UX, ...

Thank You