



*IT IS ENTIRELY POSSIBLE THAT BEHIND THE PERCEPTION OF OUR
SENSES, WORLDS ARE HIDDEN OF WHICH WE ARE UNAWARE*

Albert Einstein



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 780819.



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Using advanced ICT for supporting people with profound intellectual and multiple disabilities to 'speak' to others

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www.insension.eu

Personalized intelligent platform enabling
interaction with digital services to individuals
with profound and multiple learning disabilities



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PARTNERS:



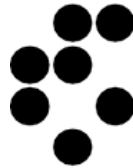
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Technological partners



Future Internet,
eInclusion technologies



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Artificial intelligence



Computer vision

Domain partners



Intellectual disability,
special education



Care provision to people
with intellectual disability



Creation and distribution of
assistive technologies



People with profound intellectual and multiple disabilities



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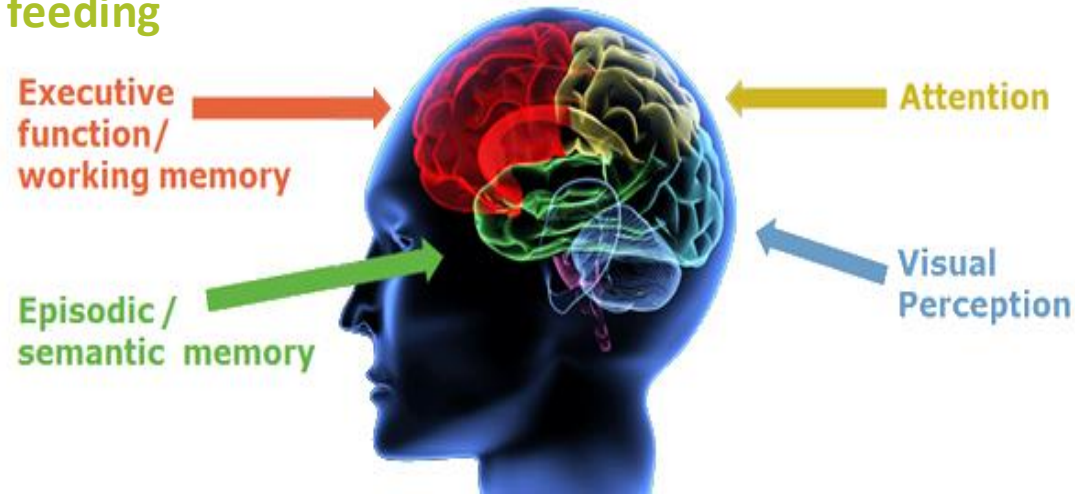


People with PIMD (1)

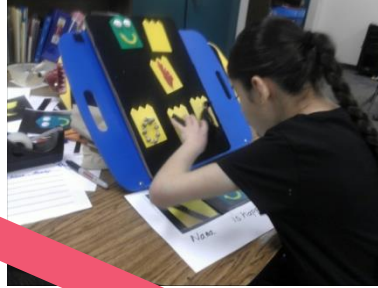
- **profound intellectual disability (IQ < 20) combined with other disabilities:** severe forms of motor disabilities, sensory disabilities (hearing or visual impairment), severe forms of epilepsy (on heavy medicamentations, frequent epileptic seizures up to grand mal)
 - **communication:**
 - (usually) no verbal language
 - often on a pre-symbolic level
 - use of unconventional behavior signals
 - **long-term high need for therapy, care, support (WHOLE LIFE!)**
- **difficult social participation!**

People with PIMD (2)

- **Tendency to distinguishable etiologies:**
 - **Genetic syndroms** (e.g. Rett-Syndrome, Lejeune-Syndrome (Cri du Chat), Angelman-Syndrome ...)
 - **Cerebral Palsy (CP)** (Pre, peri, post natal)
- **Problems with nutrition -> tube feeding**
- **Reorganized Brains**



Non-symbolic interaction (1)



Request an item



Receive the item



**AUGMENTATIVE AND ALTERNATIVE
COMMUNICATION**

Non-symbolic interaction (2)

- Reactions to the happenings around through:
 - gestures
 - facial expressions
 - vocalizations
 - gaze
- These signals are highly individual!

Example of non-symbolic behavioral signals in a person with PIMD

- **Jeremi:** boy, 9 years old
- Signals used:
 - gestures: jerky body, floppy body (head, arms), flexed arms, raising arms, flexed legs, raising legs
 - facial expressions: closed eyes, semi-closed eyes, widened eyes, raised eyebrows, corners of mouth up, frown
 - vocalizations: 7 different types, including *loud aaa*, *special breathing*, *laugh*

Non-symbolic interaction (3)

ACCEPT

(I WANT IT)



Behavioral state

PLEASURE



NEUTRAL

DISAPPROVE

(I DON'T WANT IT)



DISPLEASURE

Communication attempt

DEMAND

COMMENT

PROTEST



The goal



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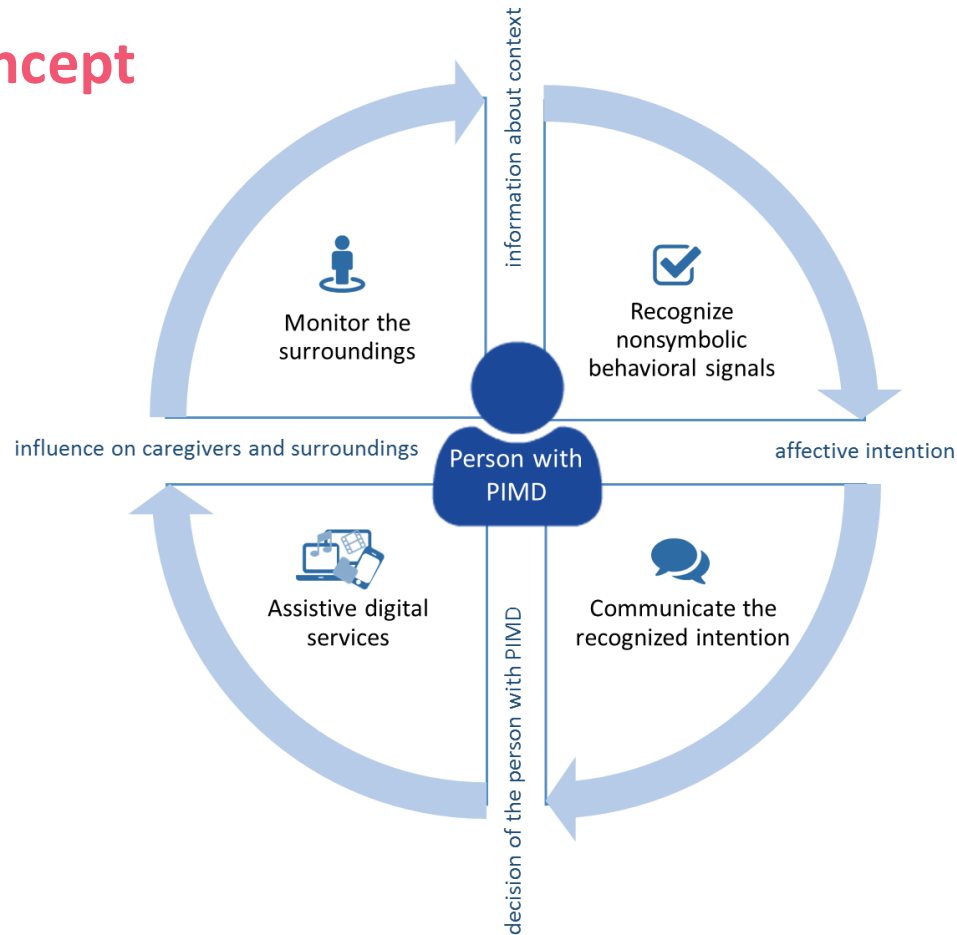
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The goal

Design and develop an ICT platform that enables persons with profound intellectual and multiple disabilities (PIMD, also referred to as PMLD - profound and multiple learning disabilities) to interact with their surroundings and, as a result, increase the ability to self-determination.

General concept





The technology



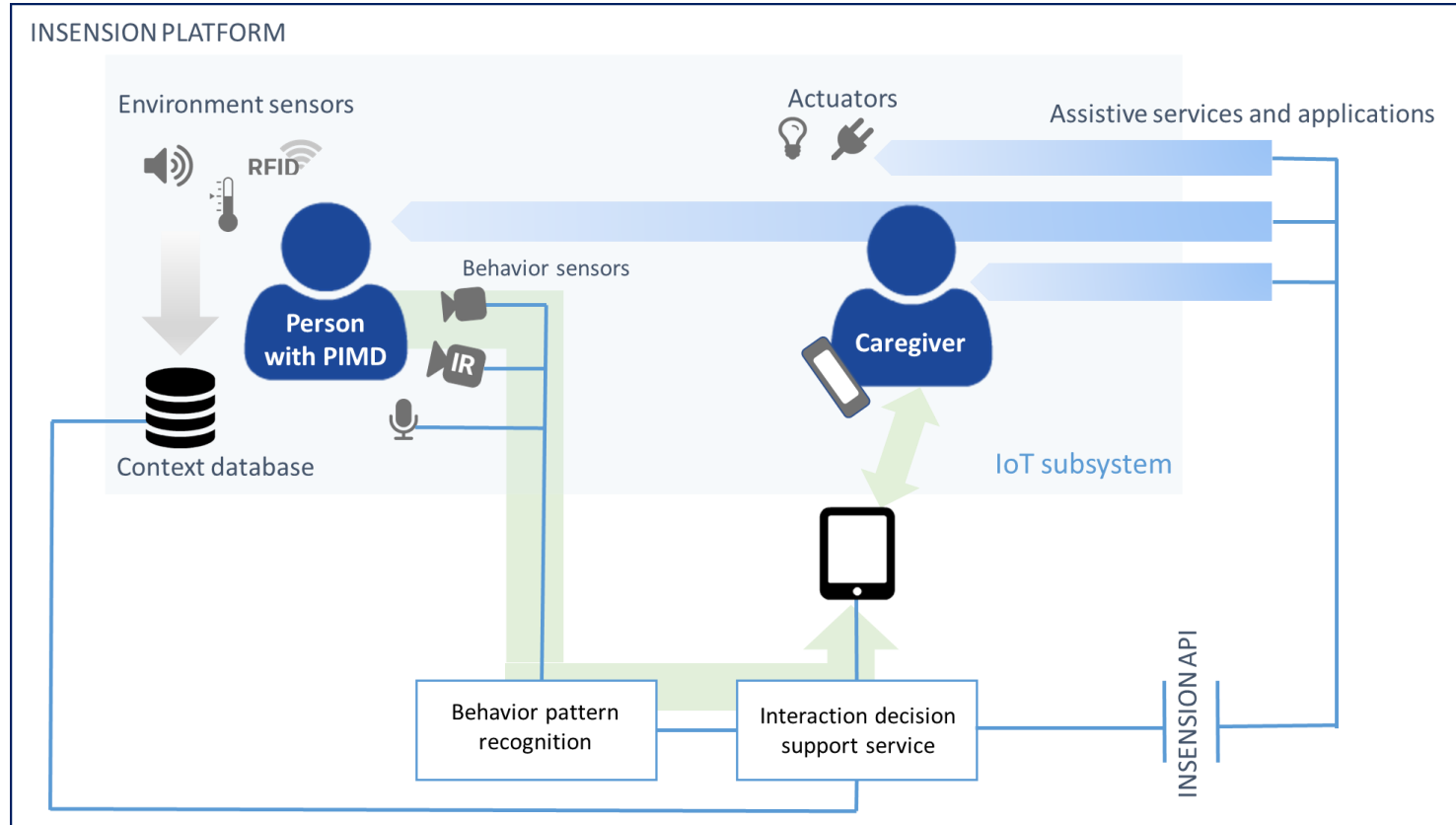
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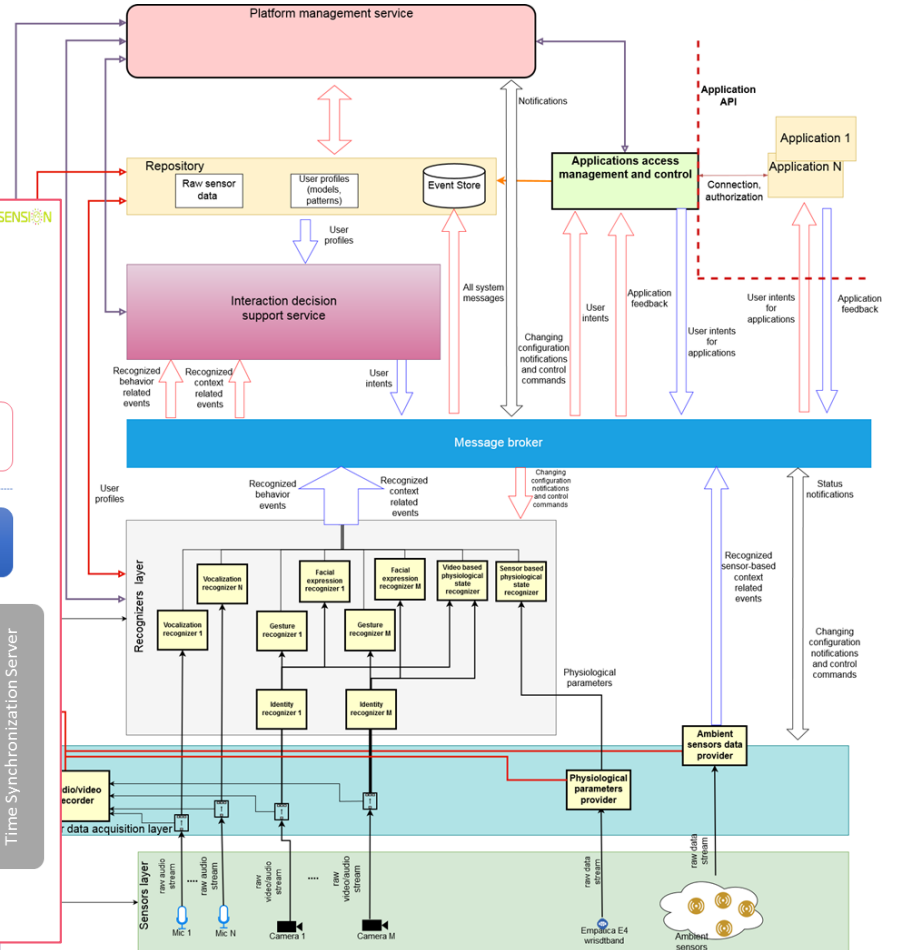
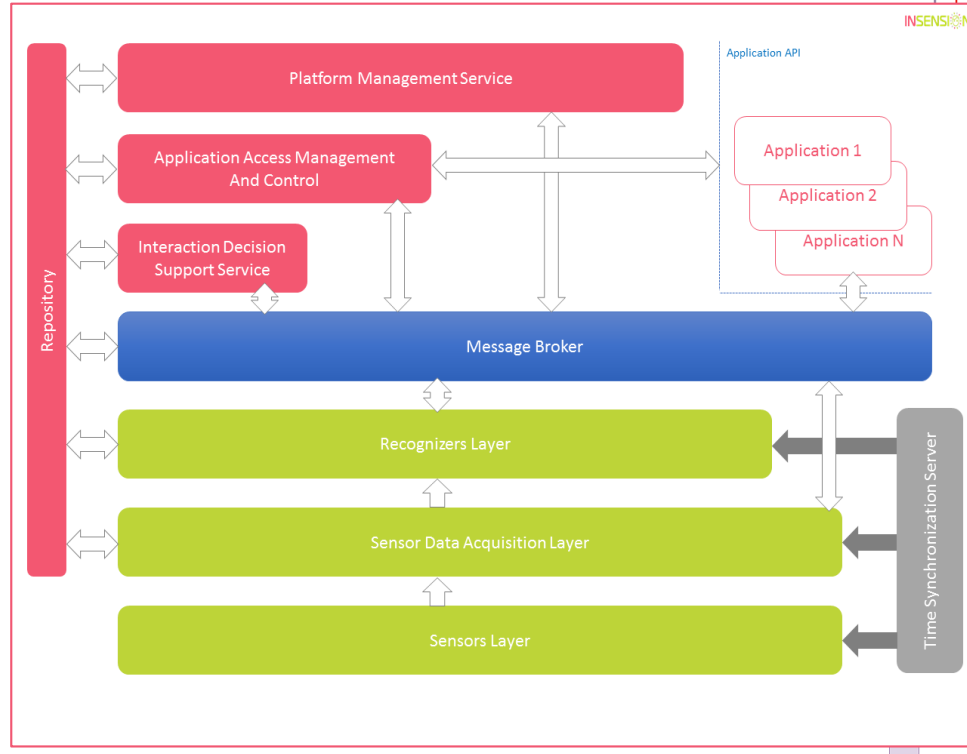
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Insension platform



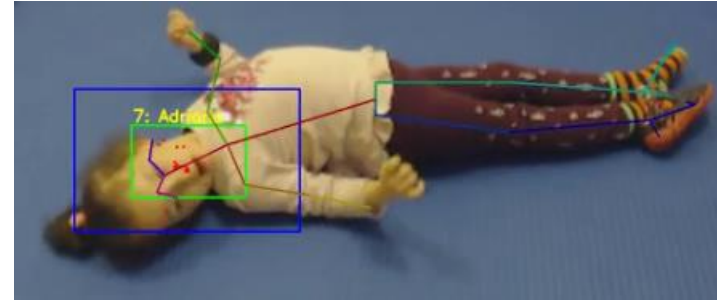
Platform complexity



Recognizers of behavioral signals



Facial expression recognizer



Gesture recognizer



Vocalization recognizer

Facial expression recognizer (1)

Recognition by face regions

- Appearance of eyes:
 - Widened eyes
 - Closed eyes
 - Semi-closed eyes
 - Winking
 - Raised eyebrow(s)
 - Frown
- Appearance of nose:
 - Nose movements
- Appearance of mouth:
 - Lip movements
 - Corners of mouth up
 - Corners of mouth down
 - Mouth wide open
- Appearance of jaw:
 - Dropping
 - Grinding
 - Biting



Facial expression recognizer (2)

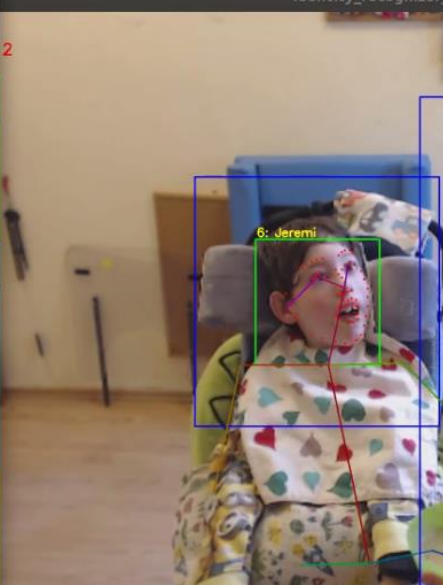
facial_expression_recognizer_13

ID: 6 NAME: Jeremi

<div>EYEBROWS</div> <div> FROWN: 0.00 RAISED: 0.99 VISIBILITY: 0.84 </div>	<div>NOSE</div> <div> MOVEMENTS: 0.14 VISIBILITY: 0.86 </div>
<div>EYES</div> <div> CLOSED: 0.00 SEMI CLOSED: 0.04 WIDENED: 0.96 WINKING: 0.00 VISIBILITY: 0.85 </div>	<div>MOUTH</div> <div> WIDE OPEN: 1.00 CORNERS UP: 0.00 CORNERS DOWN: 0.00 LIPS MOVEMENTS: 0.00 VISIBILITY: 0.81 </div>
<div>JAW</div> <div> DROOPING: 0.00 GRINDING: 0.39 BITING: 0.61 VISIBILITY: 0.71 </div>	

(x=767, y=581) ~ R:255 G:255 B:152

identity_recognizer

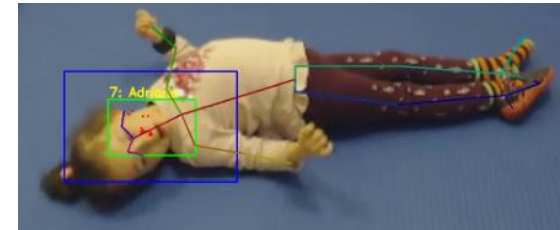


Scratch 69
78
REPOSITORY_API_V2_CONFIGS_1
Run: main

Gesture recognizer (1)

Recognition by body parts/regions

- Body posture:
 - Jerky
 - Leans to side
- Appearance of head:
 - Floppy
 - Shaking
 - Nodding
 - Raising
 - Turns to side
 - Leans to side
- Appearance of arm:
 - Rigid
 - Floppy
 - Jerky
 - Outstretched
 - Flexed
 - Raising
 - Close to the body
- Appearance of hand:
 - Hand on hand
 - Hand on head
- Appearance of leg:
 - Outstretched
 - Flexed
 - Raising
 - Rubbing
- Appearance of feet:
 - Foot on foot



Gesture recognizer (2)

ID: 7 NAME: Adriana	
LEFT HAND HAND ON HAND: 0.00 HAND ON HEAD: 0.00 VISIBILITY: 0.82	RIGHT HAND HAND ON HAND: 0.00 HAND ON HEAD: 0.00 VISIBILITY: 0.51
LEFT ARM OUTSTRETCHED: 0.00 FLEXED: 1.00 RAISING: 0.82 CLOSE TO BODY: 0.01 RIGID: 0.10 FLOPPY: 0.00 JERKY: 0.00 VISIBILITY: 0.79	RIGHT ARM OUTSTRETCHED: 0.86 FLEXED: 0.00 RAISING: 0.00 CLOSE TO BODY: 0.38 RIGID: 0.05 FLOPPY: 0.00 JERKY: 0.00 VISIBILITY: 0.62
LEFT LEG OUTSTRETCHED: 1.00 FLEXED: 0.00 RAISING: 0.41 RUBBING: 0.00 VISIBILITY: 0.33	RIGHT LEG OUTSTRETCHED: 1.00 FLEXED: 0.00 RAISING: 0.50 RUBBING: 0.00 VISIBILITY: 0.44
MOVEMENTS OF HEAD TURN TO SIDE: 0.00 RAISING: 0.80 TURN DOWN: 0.09 NODDING: 0.00 SHAKING: 0.10	BODY POSTURE LEAN TO SIDE: 1.00 JERKY: 0.00 VISIBILITY: 0.57
POSITION OF HEAD LEAN TO SIDE: 1.00 FLOPPY: 0.00 VISIBILITY: 0.69	FEET APPEARANCE FOOT ON FOOT: 0.88 VISIBILITY: 0.26

NUM GPUS: 1
NUM PEOPLE: 1
FPS: 22.74



top, right, bottom, left = bbox

Identifier

```

2020-09-14 18:51:13,312 - INFO - Unknown person detected, Content message: {'personId': '7', 'pr
2020-09-14 18:51:13,323 - INFO - FPS: 22.74
2020-09-14 18:51:13,477 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,487 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,498 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,684 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,613 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,622 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,725 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,734 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,743 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,856 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,868 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,879 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,982 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
2020-09-14 18:51:13,988 - INFO - PIMO identified, Content message: [{'personId': '7', 'pr
  
```

Vocalization recognizer

Adriana

Vocalization name
eee
aaa
grunt
moan
eeh
laugh

Jeremi

Vocalization name
specific_breathing
aaa
crying
aeaeae
eee
cough
nge



Context of behaviors (1)

Reaction	Person A	Person B	Person C	Person D	Person E
Positive	Swinging	Singing	Massager	Music/musical instrument sounds	Music/playing with instruments
	Listening to music	Listening to music	Music	Swinging	Listening to singing and other people talking
	Massager (vibrations)	Playing with favorite toy - the pig makes noises/sounds	Movies	Backyard (she calms down when she looks through the window and when the caretaker says they'll go outside)	Playing with beads
	Special sympathies: -A. N. (caretaker) -mother -father -grandfather	Sounds of vehicles and animals	Smelling flowers	Special sympathies: - M. (group coordinator) -K. (person from Kamyk group)	Special sympathies: -A.J.(caretaker from the group) -mother -father -sister
		"Talking" to others - people making funny sounds	Favorite toy - rabbit		
		Swinging	Lights		
		Special sympathies: -mother -grandmother -S. (caretaker at school) -therapists:M., K., K., A., B., M., R.	Other people's voices		

Context of behaviors (2)

Reaction	Person A	Person B	Person C	Person D	Person E
Negative	Cold objects	Crowded places	When it's cold		Large group of people when there's noise
	Change of position to sitting down	Sounds of violin, ambulance, fire brigade siren	Being alone		Change of position
			Sudden, loud noises		Eating and drinking
			Unknown people (he ignores them)		

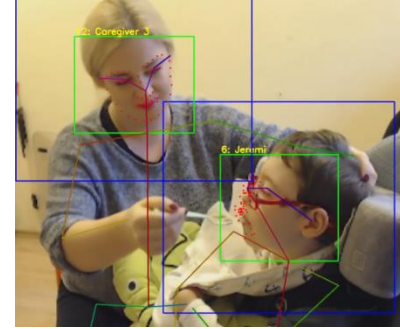
Example likes/dislikes of a person with PIMD

- Jeremi likes:
 - cars (sounds of cars, e.g. racing)
 - lights
 - music (jazz music)
 - swinging
 - people, with several special sympathies (family, teachers at kindergarten)
- Jeremi dislikes:
 - cold
 - no attention

Context recognizers



Ambient sounds recognizer



Identity recognizer



Ambient sensors

Feedback
from assistive
applications

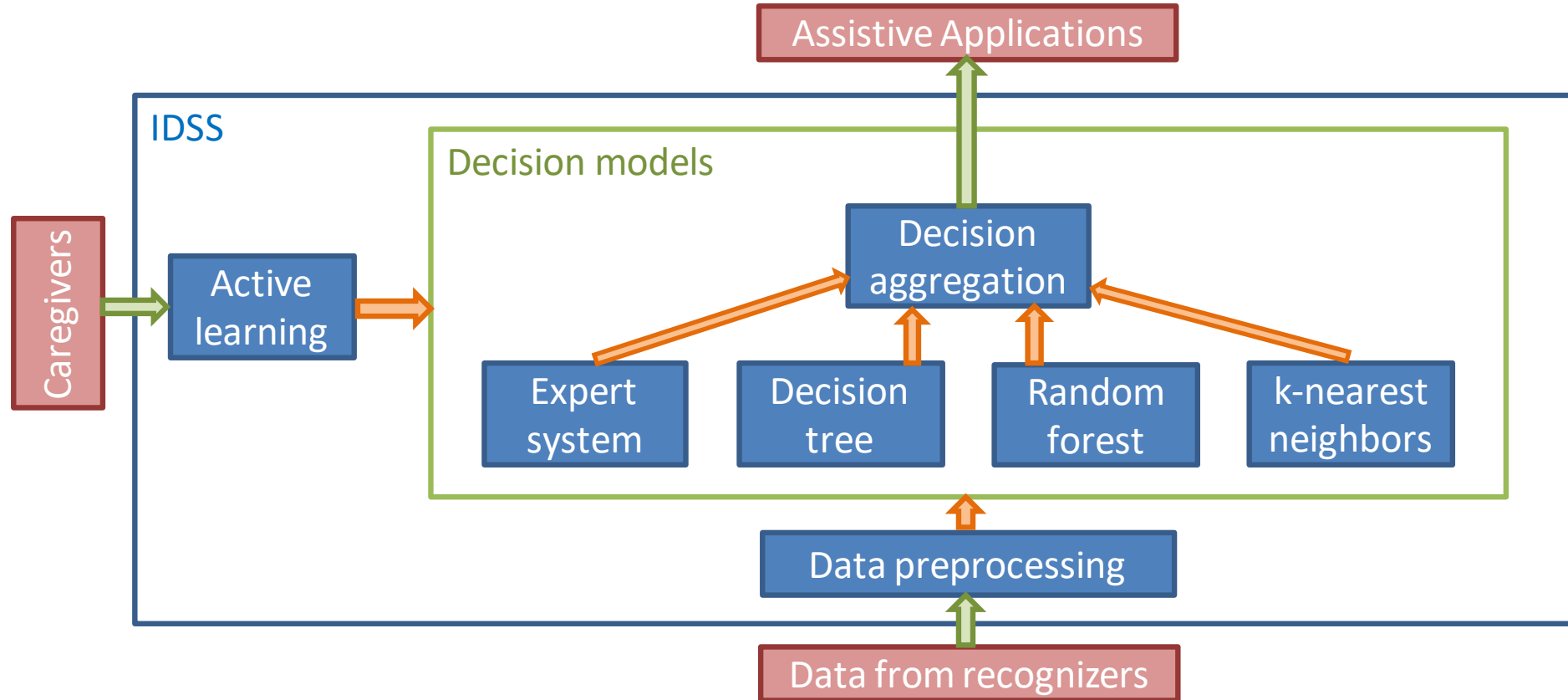


Object recognizer

Interaction decision support (1)

- **Objective:** interpret the data collected by recognizers as *user intents*
 - **A *user intent* contains:**
 - behavioral state of the user (PLEASURE/DISPLEASURE/NEUTRAL) and/or
 - communication attempt of the user (DEMAND/PROTEST/COMMENT)
- plus**
- potential causes of the behavior related to the current user intent

Interaction decision support (2)





Application of the Insension platform



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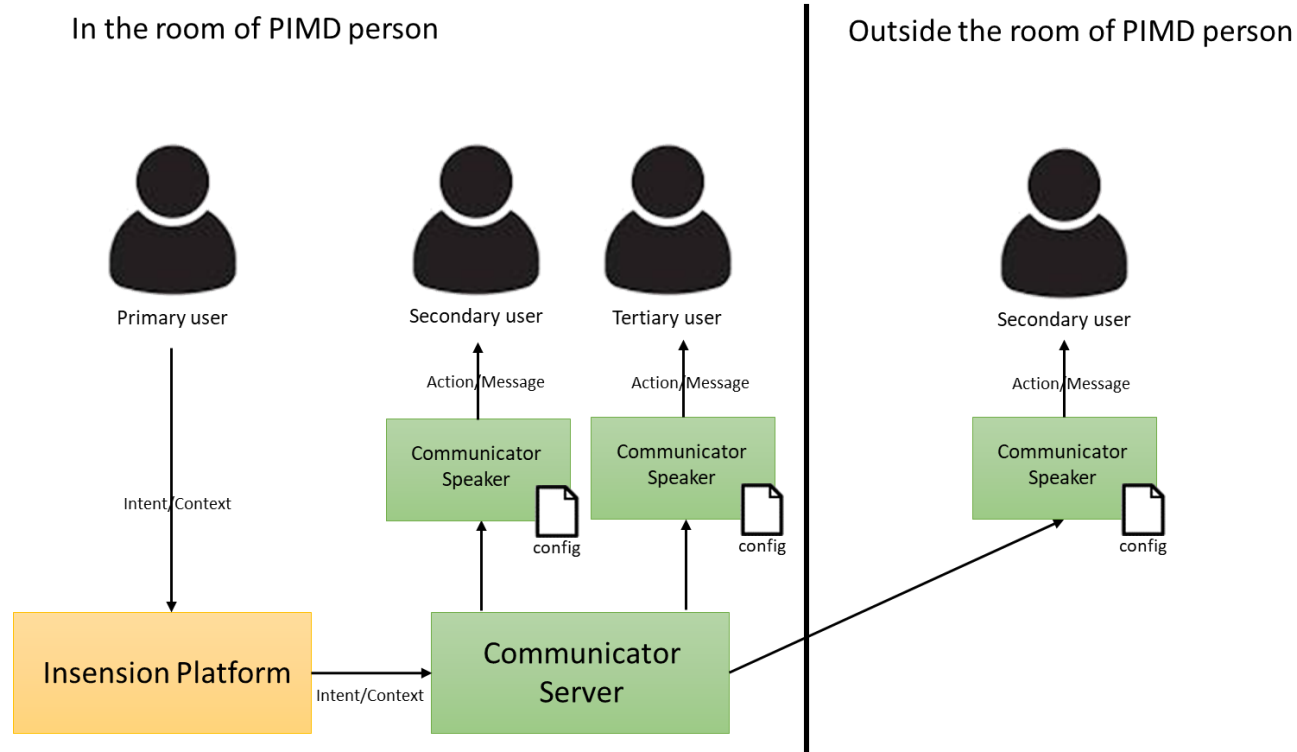


Assistive applications

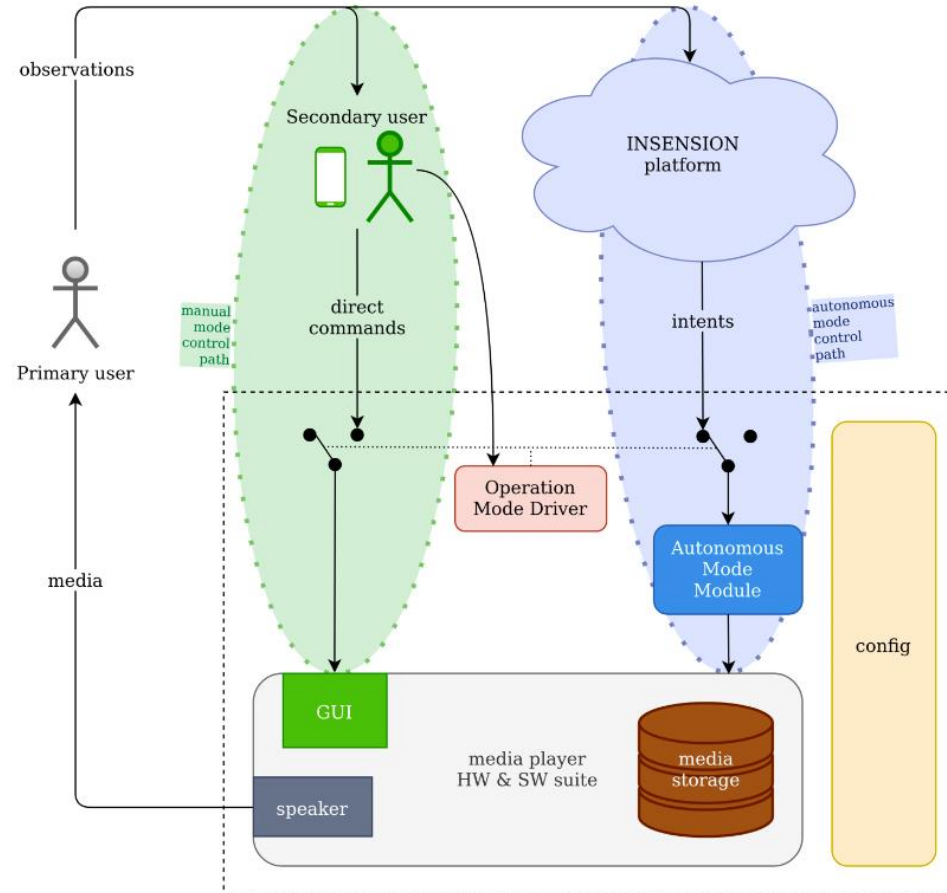
- **Goal of the INSENSION platform:** provide information on the current need of the end user to external applications which are capable of acting on behalf of the end user
- **Example (pilot) applications:**



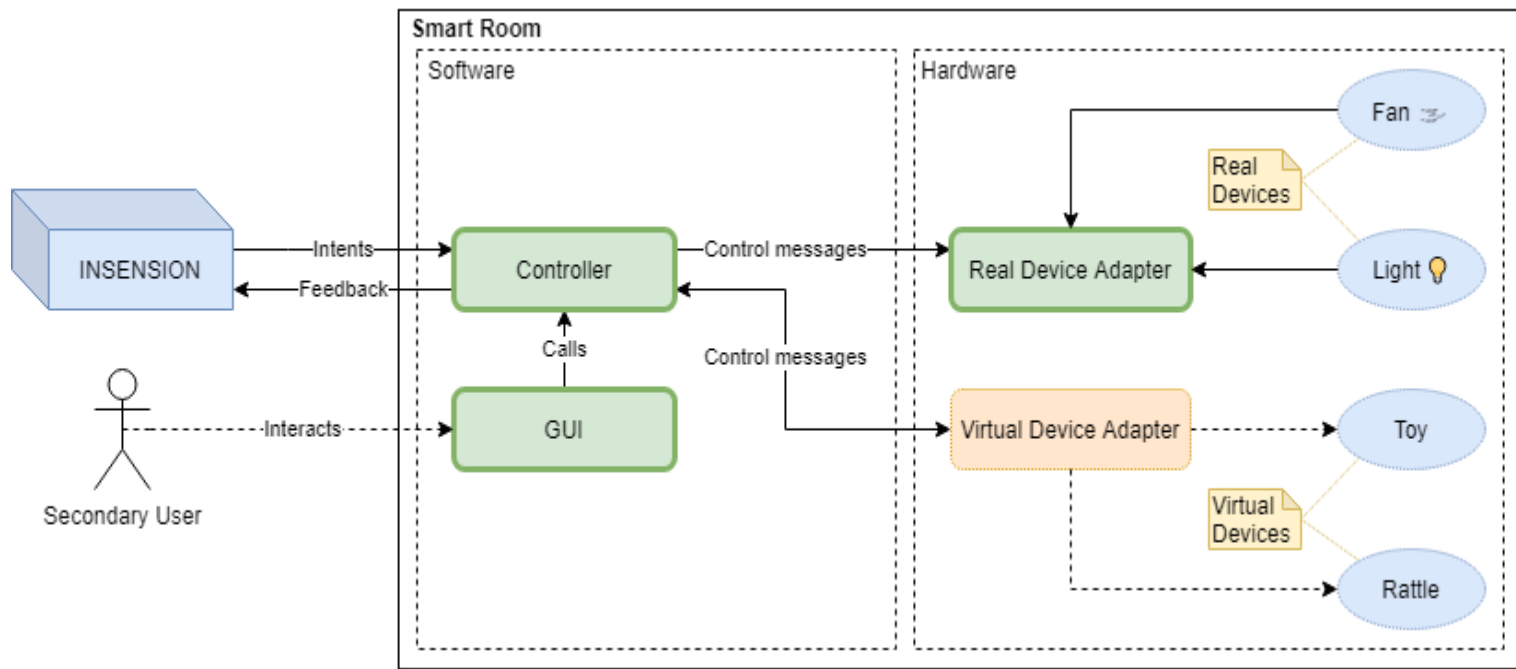
Communicator



Media player



Smart room

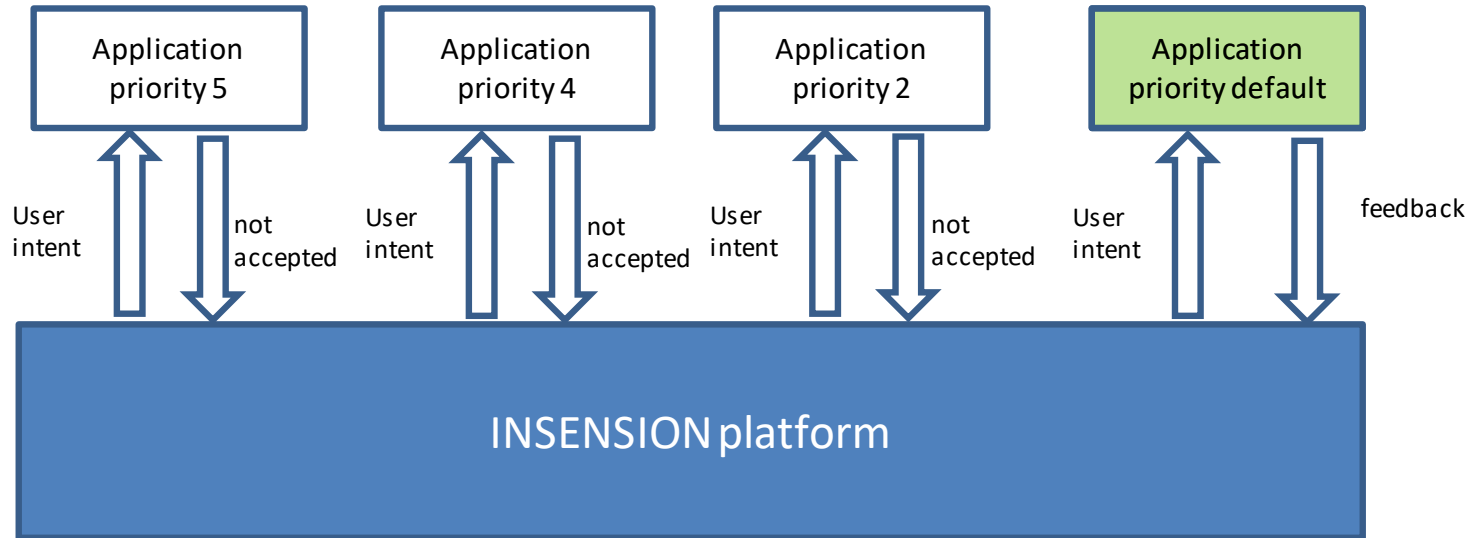


Applications prioritization (1)

- Applications receive primary user intents in order of priority until the one wishing to process the intent informs the platform it will do so
- Many applications can have the same priority which allows them to process the same primary user intent
- A selected application acts as *default* (default application has the lowest priority)
 - If no application with higher priority decides to process a given primary user intent, the default application must process it
 - Modes
 - Mode 1 - the default application receives the intent only when it is not handled by any other application
 - Mode 2 - the default application receives the intent regardless of whether any other application handles it too

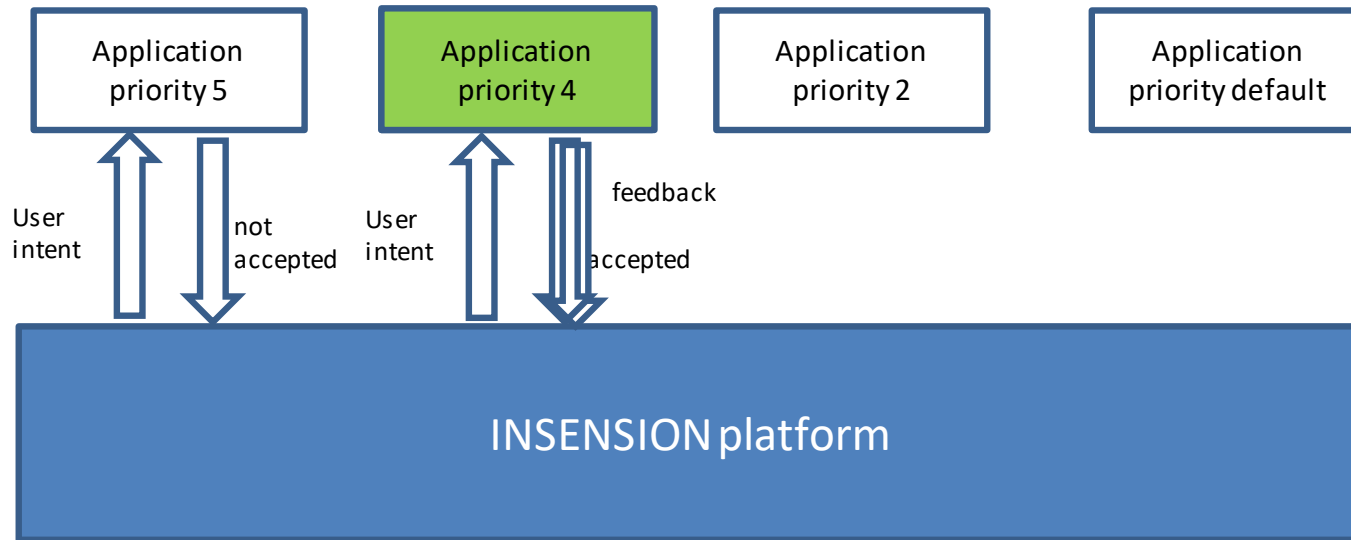
Processing user intents by applications (2)

Mode 1 – the default application receives the intent only when it is not handled by any other application



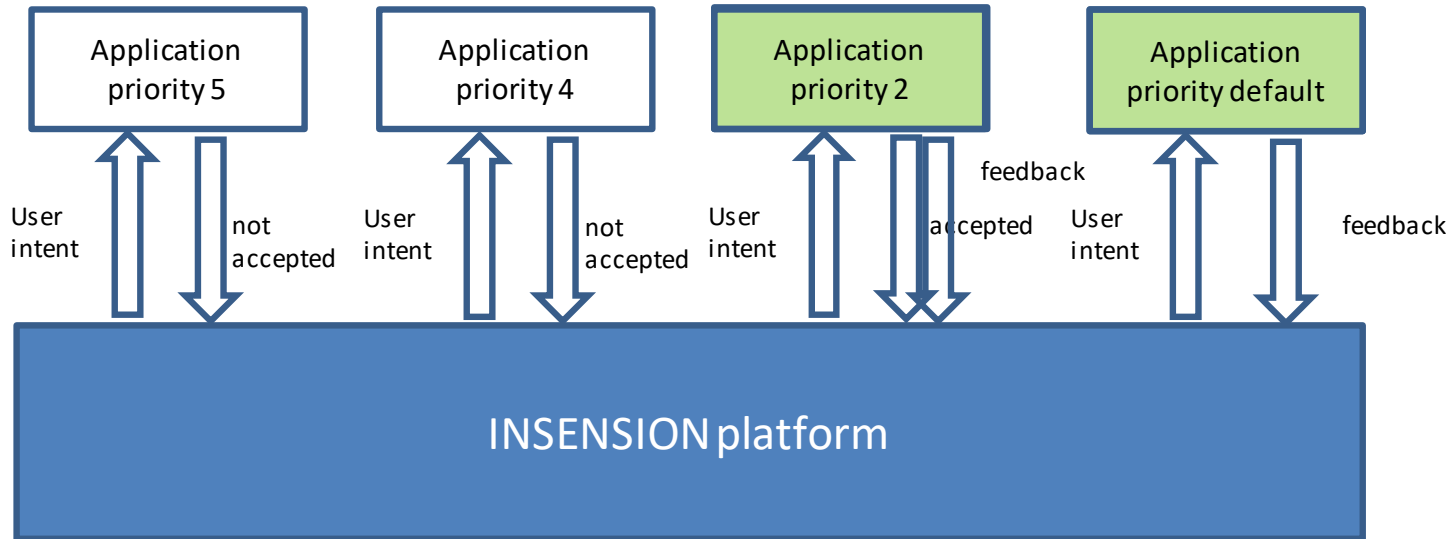
Processing user intents by applications (3)

Mode 1 – the default application receives the intent only when it is not handled by any other application (intent consumed by application with priority 4)

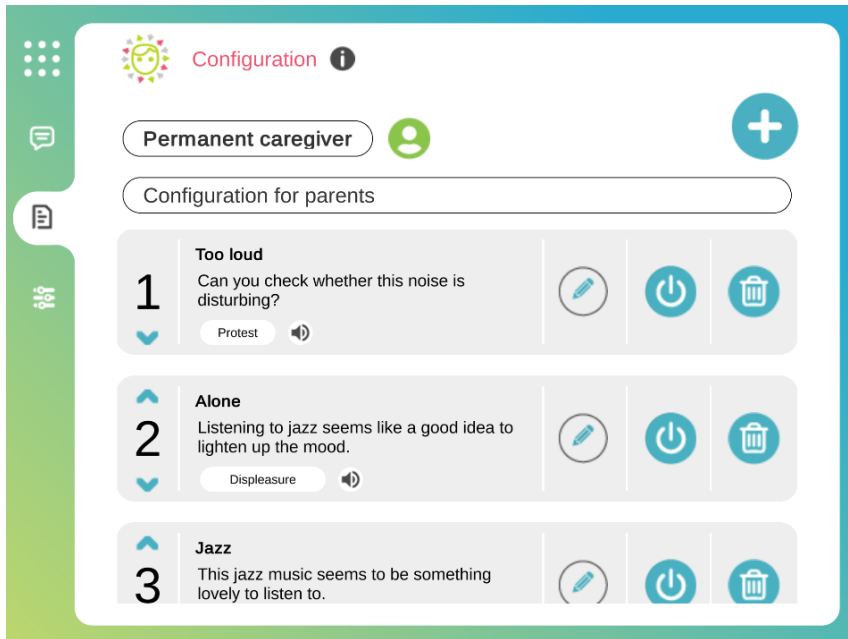


Processing user intents by applications (4)

Mode 2 - The default application receives the intent regardless of whether any other application handles it too



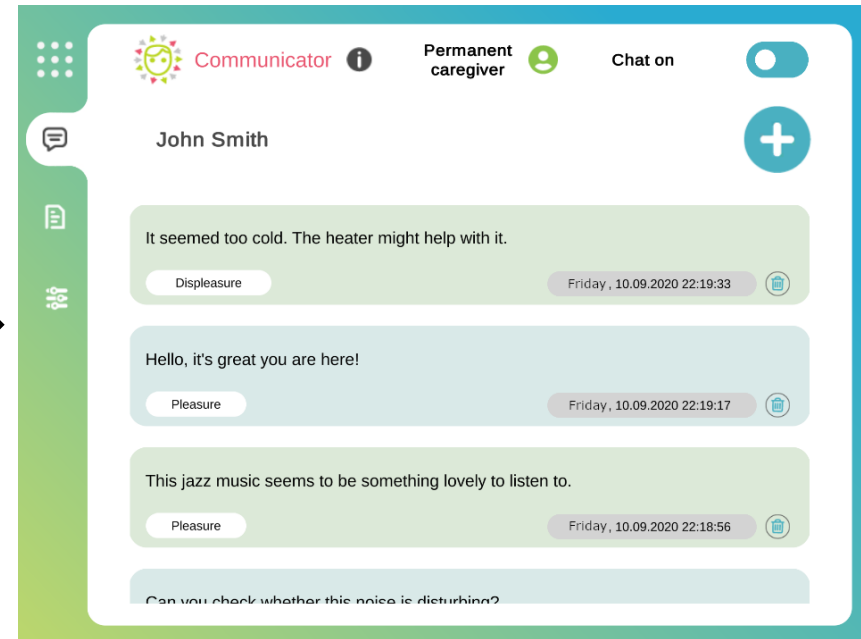
Configuration of applications (1)



The 'Configuration' app interface shows a list of rules for a 'Permanent caregiver'. The rules are numbered 1, 2, and 3. Each rule has a title, a description, and three action buttons: a pencil icon for editing, a power icon for enabling/disabling, and a trash icon for deleting. Rule 1 is titled 'Too loud' and has a 'Protest' action. Rule 2 is titled 'Alone' and has a 'Displeasure' action. Rule 3 is titled 'Jazz' and has a 'Displeasure' action.

Rule Number	Rule Title	Rule Description	Action
1	Too loud	Can you check whether this noise is disturbing?	Protest
2	Alone	Listening to jazz seems like a good idea to lighten up the mood.	Displeasure
3	Jazz	This jazz music seems to be something lovely to listen to.	Displeasure

Rules

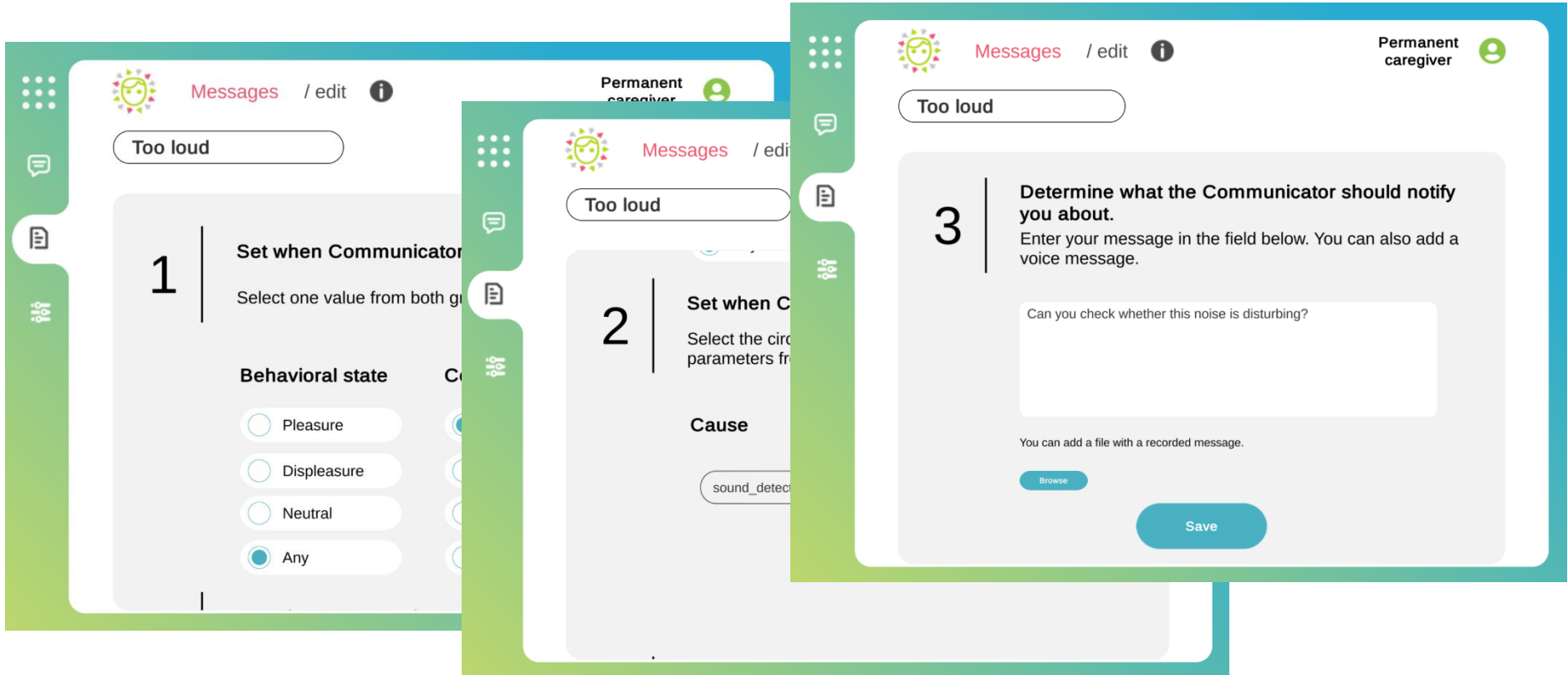



The 'Communicator' app interface shows a chat conversation with 'John Smith'. The chat history includes three messages: 'It seemed too cold. The heater might help with it.' (Displeasure), 'Hello, it's great you are here!' (Pleasure), and 'This jazz music seems to be something lovely to listen to.' (Pleasure). The messages are timestamped and include a trash icon for deletion. The bottom of the screen shows the start of a new message: 'Can you check whether this noise is disturbing?'.

Message	Emotion	Timestamp
It seemed too cold. The heater might help with it.	Displeasure	Friday, 10.09.2020 22:19:33
Hello, it's great you are here!	Pleasure	Friday, 10.09.2020 22:19:17
This jazz music seems to be something lovely to listen to.	Pleasure	Friday, 10.09.2020 22:18:56

Actions

Configuration of applications (2)



The image displays three overlapping screenshots of the INSENSI application configuration interface, illustrating the steps to configure a message.

Step 1: Set when Communicator

Select one value from both groups.

Behavioral state

- ☐ Pleasure
- ☐ Displeasure
- ☐ Neutral
- ☒ Any

Step 2: Set when C

Select the circle parameters from the list.

Cause

Step 3: Determine what the Communicator should notify you about.

Enter your message in the field below. You can also add a voice message.

You can add a file with a recorded message.



Potential enhancement of interpretation results



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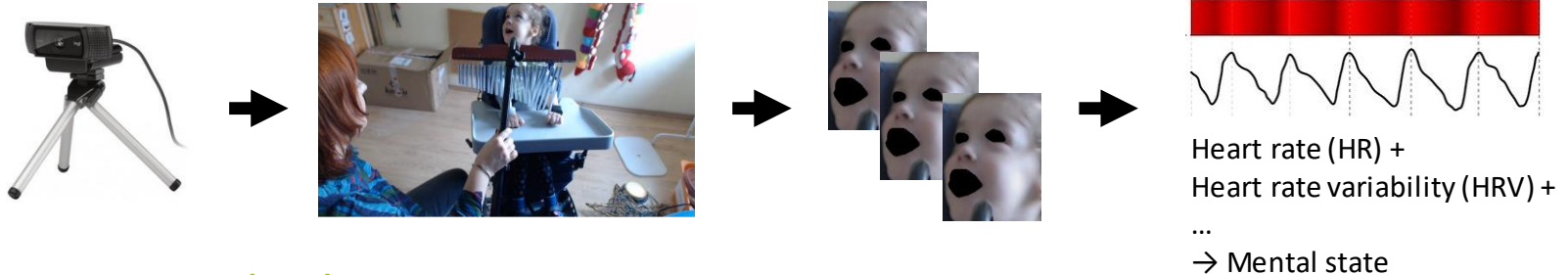
Additional study: influence of monitoring physiological response on the platform accuracy

Literature has suggested that including information on physiological response of people with PIMD might help to interpret their behaviors:

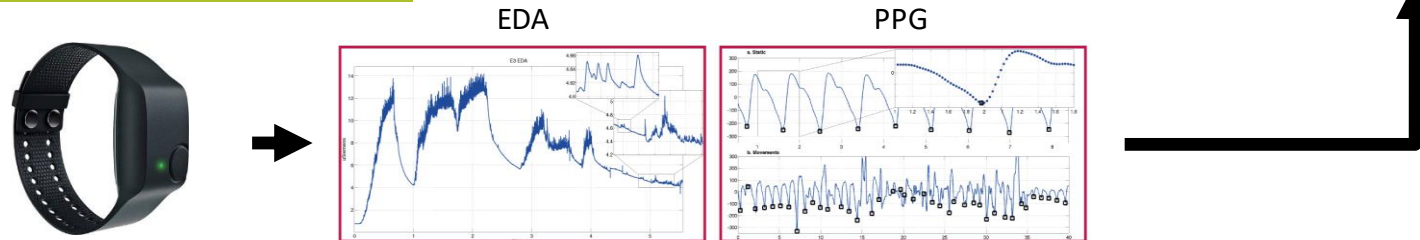
- *„heart rate and skin temperature can give information about the emotions of persons with severe and profound ID”* [Vos et al. 2012]
- *„frequent consistent physiological reactions”* to stimuli [Lima et al. 2013]
- *„a shallow, fast breathing pattern, used less thoracic breathing, had a higher skin conductance and had less RSA when experiencing positive emotions than when experiencing negative emotions”* [Vos et al. 2010]

Physiological parameters monitoring

- Contact-free monitoring:



- Contact monitoring:





Important questions



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Important research (and design) questions

- Is building the INSENSION system possible from the technical point of view?
- Is the INSENSION system *smart* enough to accurately act on behalf of the primary end user?
- Does the INSENSION system actually support people with PIMD?
- To what extent should the INSENSION system act on its own once it is able to recognize the meaning of the given behavior of the person with profound disability?

Should we use AI for supporting people with PIMD?

- *(We believe)* AI can empower people with profound intellectual and multiple disabilities to take actions themselves, especially when no direct support person is around
- AI system such as INSENSION is sort of a prosthesis of verbal communication for a person who is biologically unable to use verbal communication
- Such a system is similar to:
 - wheelchair that allows people with motor impairment to move around
 - white cane that allows people with visual impairment to scan surroundings
 - ...

The answer

**Not applying Artificial Intelligence on people with PIMD
due to their incapability of consenting to it
would refuse them the possibility to benefit from the potential
of achieving a level of independence**



Thank you for your attention!

Further information on insension.eu

Find us on Facebook: www.insension.eu/fb



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