Sensor Signal-based Learning Improvement Framework for Intellectually Disabled (ID) Child Education

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Abstract: According to World Health Organization (WHO), persons with cognitive impairments such as dementia, aphasia and development disorders account around 1.25% of world population. Specifically, there are 31 million individuals including 35.29% children with Intellectual Disabilities (ID) in India. Only 1% of these children have access to school and majority of them fail to express their needs and thoughts in classrooms. Their learning skills can be enhanced by incorporating wireless sensors in Assistive Technologies (AT). Rapid growing signal-based wireless sensors with smart devices motivate the development of many learning methodologies for ID school Education. This paper aims to design, implement and evaluate an Alternative and Augmentative Communicate (AAC) system for ID school education by validating, utilizing and manifesting signal-based wireless sensors. This context-based AAC employs the Low Power Bluetooth (BLE) technology for the nonverbal interaction in class room teaching. The system utilizes the high indoor tracking accuracy of signal-based BLE beacons to acquire the effective context from backend application server and presents the symbols in smart devices.

The children communicate with visual objects like apple at an appropriate time i.e. during lunch time by utilizing smart phone or tablet. The system incorporates the involvement of user management such as login and profile maintenance for teachers and caregivers through smart devices.

Keywords: Nonverbal communication, Cognitive, visually perceive, context-aware, beacons, Disability

1. Introduction

Intellectually impaired (ID) school educators continue to focus on AAC (Alternative Accelerate Communicate), methodologies that do not require voice and messages that account for communication in classrooms. In the mid-1990s, the sectors of AAC took shape for an ever greater interest in trans-disciplinary cross-domain analysis on research of AAC technologies. It includes the use of external materials or equipment including the photo board with a set of graphical symbols [1]. Across the world, only 2.73% of behavioral and learning disabilities have been utilizing the resources of AAC as their main form of learning. And just approximately 13.86% of students with disabilities depend on AAC resources for their everyday conversations. However, it has been stated that around 45.60% of ID community will currently use basic symbolic procedures, such as image cards.

Figure 1. Interpretation of BTE beacons and students activities with the smart devices.

In India, the NISH (Institute of National Speech & Hearing) is noticed that it is tougher to hear the ID children to notice for their parents or teachers. In addition to AAC devices, VOCA and PECS are used for children with disabilities, where learners choose images for phrasing. These methodologies were traditionally developed for children with serious speech as well as motor disorders who had trouble with communicating and reading, but could not comprehend the speech of other individuals.

The rest of the paper focus on the following. Section 2 presents an overview of cognitive learning technologies where as in section 3 the proposed methodology is presented. In section 4, the real time system implementation is discussed and finally the experimental testimony is given in section 5.

2. Cognitive Learning Technologies

Regular human contact is basically meaning-based, whereas context is not confined to the geographical position of the interaction; it rather includes environmental factors such as time, individuals and social interactions in the communication. The feeling and interpretation of human users senses and interprets certain situational features and can influence the content of communications messages. In the last two decades, a significant amount of effort has been made on context-aware applications and solutions. In specific, many context-aware AAC implementations were suggested and used by cortical paralysis and aphasia users. The majority of current AAC systems are focused on indoor GPS or Wi-Fi position tracking methods.

However these approaches have functional drawbacks to help cognitively efficient background identification in indoor settings [3]. In addition, after reviewing AAC applications, it has been observed that most of them are autonomous offline implementations, meaning that several of them may not benefit from new technical paradigms like that of the Internet of Things and Engineering and Technology. With this context, we are advised to use this approach to plan, introduce and measure an AAC framework for children with learning disabilities by validating, explaining, and leveraging the power of BTE technologies to facilitate day-to-day connectivity for users with severe memory limitations.

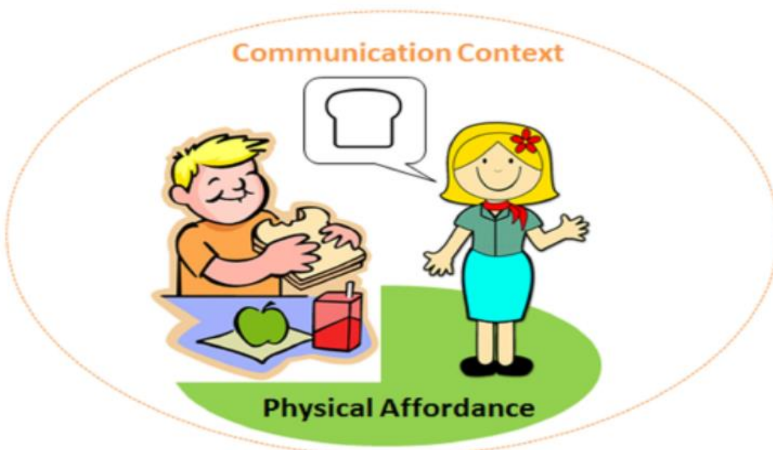

Figure 2. Nearby physical items, such as bread, apples, and drinks may provide real physical possibilities.

3. Methodology

We include the theoretical foundation for our methodology design in that same portion. In human speech, we first examine the function of knowledge and the physical world.

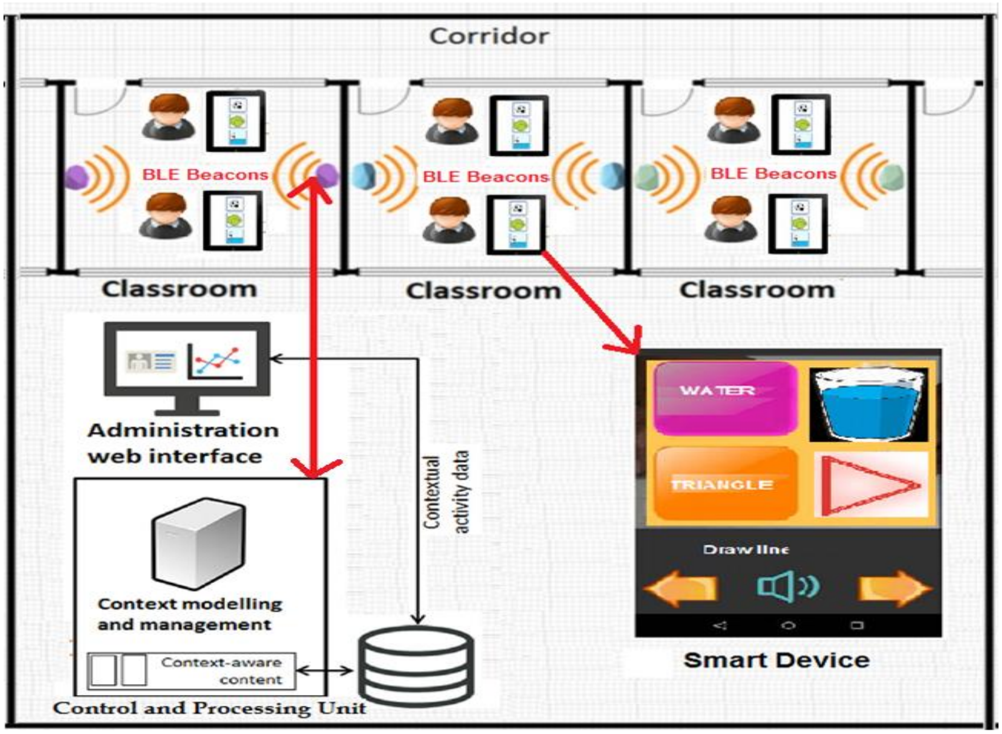

Figure 3. **Typical components that constitutes the learning Frame work for the ID school Children.**

We then provide a short description of human executive function and address the cognitive features of our potential end users. Finally, in promoting cognitively efficient background understanding, we address the special attribute of BTE beacon-based similarity detector technologies [4]. We introduce the architectural concept of an IOT-based systems at either end of that kind of portion, which we have proposed from the ideas and innovations examined. The APL is a second barrier for persons with IDs sensitivity among career's and health workers sometimes faced by people with Intellectual disabilities; Cognitive and dementia disorders. These impairments may enable the usage of devices and hence users' needs the ID are always taken into consideration more frequently.

3.1. School Environment and context

The indoor consumer activity with a multi-sensor has been calculated. In our first trial, we tested our findings against implicit responses from users and gained considerable consistency when the users displayed presentations they were involved in. We also issued new guidance for enhancing our evaluation process, such as understanding the experimental development performance and revising an application to our programme. We checked the utility of the knowledge presentation utilizing consumer experience information to validate its usefulness. In the two experiments, we increased the exact user movement knowledge with an intelligent clock. We predict the knowledge on user actions in more diverse contexts, with case examples and respondents growing.

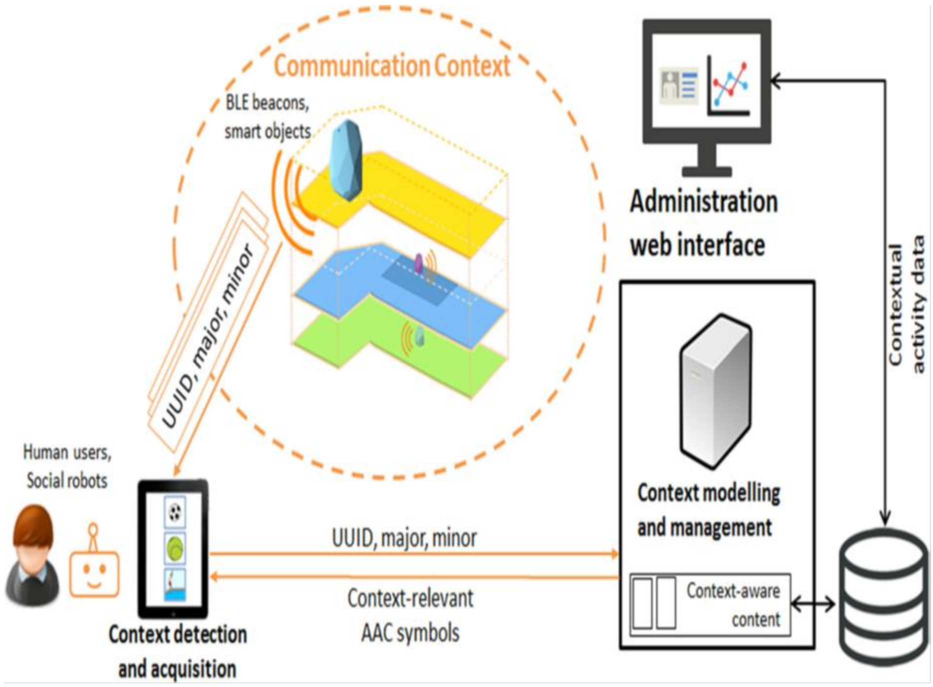

Figure 4. Context-based AAC system design with various components

Human correspondence does not only include origins and recipients, but even communications, like contexts, channels and signals. In addition, the mechanism of human contact is not only symbolic but often includes tactile effects including stimulations from the region. There is a link between human perception, perceived position of the body and environmental conditions. The physical condition in which correspondence occurs can affect the substance of messages. The concepts are shown in Figure 6.

Based on the current cognitive psychology, the minimization of redundant cognitive inputs, including incredibly restricted memory retention, will reallocate cognitive energy. Context knowledge functionality requires the functionality to view just the collection of knowledge artifacts specifically relevant to the person's condition. This function is important for potential users with intellectual capability deficits, such as schizophrenia, ID and cerebral disability.

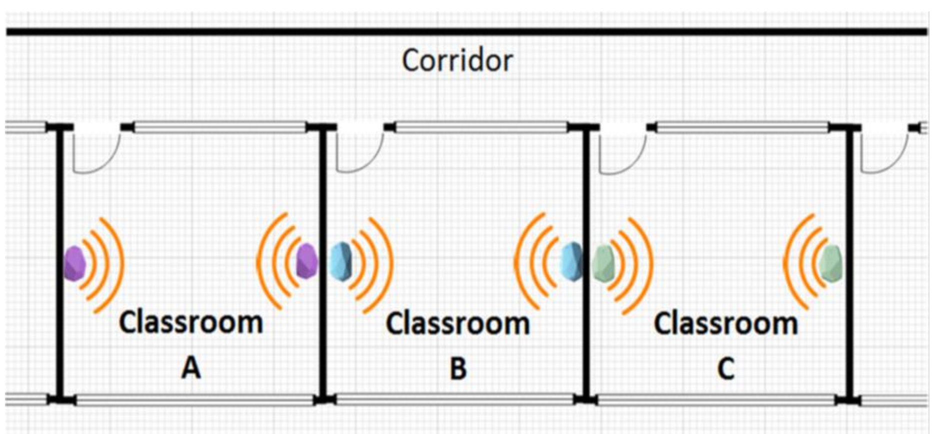

Figure 5. BTE beacons physically deployed on a specific floor.

3.2. Bluetooth enabled classrooms for context-aware

Bluetooth v4.0 protocol is termed as BTE technology. It is developed with IOT in view for wireless hardware connectivity, featuring low cost, low wattage usage, and compatibility with multivendor. Devices promoting BTE technologies will continuously range and track BTE wireless signals being sent by BTE beacons in order to allow various applications for position and background. Finger printing tests have shown substantial BTE positioning enhancement over de-facto detection methods, particularly throughout the indoor climate, such as GPS and Wi-Fi optimization.

Table 1. Precision and perceptual performance of GPS, Wi-Fi and BTE beacons Indoor Placement

Location detection technology	Tracking accuracy in indoor environment	Cognitive effectiveness of contextual stimuli
GPS	Does not work in indoor environments.	(Not applicable inside physical buildings.)
WiFi indoor positioning	< 8.5 m error 95% of the time [35].	Not supported.
BLE beacons	< 2.6 m error 95% of the time [35].	Supported.

According to scientific studies in neurophysiology, spatial structure in the human cerebral cortex may impact visuo-spatial perception and contextual experiences. In standard psychophysical research conditions, the measurement gap between the goal object as well as the human investigator is 6m. This gap lies beyond the spectrum of BTE positioning precision, but outside that of traditional methods of tracking devices, such as internal positioning for GPS and Wi-Fi. In Table I, we summarize the indoor precision of monitoring and cognitive efficacy of contextual stimuli across different position detection technologies.

4. System Design in Real-Time

In this article, we suggest utilizing the strong indoor monitoring precision of BTE beacons to accomplish our system's behaviorally efficient detection and extraction. This is seen in Figure 8 where a student physically perceives and communicates cognitively with material objects at a specific point of time within sense, whereas the BTE-based AAC programme senses some BTE beacons found beyond the field of cognitively efficient contextual stimulus and shows only the AAC icons that denote objects located inside the specific context.

4.1. Inquiry by Visits to ID schools

The hierarchy of conversation requires an active local chart and their control partnership. For example classrooms are in blocks and floors in the education building. BTE beacons are linked to the AAC devices in various locations to facilitate system-wide analysis and content delivery. The smallest unit of the hierarchy is AAC key to interface icons, in the case of pictures marked with semantine marking, which are knowledge artifacts which rely on the positions and are displayed to users via smart devices of students such as tablets or social robots running over OS- 8 and Android-5 or higher.

4.2. Functions and goals of the System

In order to collect the understandings of the target students, their everyday contact patterns and their organization culture, we conducted contextual surveys and field audits at the inception of the device design steps. We also implemented a participatory conceptual model that is effective with information systems for developmentally disabled children's consumers. Our project staff involved clinicians along with school teachers as well as communications developers and professional developers. Opinions from an elderly school student were often collected and inserted into the architecture for the user interface.

Our system's targeted respondents are students from a Vijayawada based special education school. The school offers primary schooling for students with a mild IQ ID of 40 to 55. Individual school pupils also suffer numerous difficulties and deficiencies in general, such as highly personality disorders. A large number of students were diagnosed as verbal and non-verbal clinically.

4.3. Architecture

The system objective is to provide context-based AAC services for the primary ID school. The following three assumptions have been defined for the context-specific investigations and practical demonstrations:

1) Context recognition and acquisition by the students through BTE location range detection.
2) Providing context modeling and interest AAC symbols of ID communication.
3) Suitable user interface for the individuals with various levels of mental and motor impairments.
4) Access controls for user groups and caregivers, such as login and consumer profile management.
5) Automatic series of patterns of subjective transactions for the healthcare monitoring system.

5. Experimental Testimony

The specificity of our approximation is at class rooms, as seen in the confinement hierarchy in Figure 8. To obtain the most detailed positioning outcomes, we used the physical interior design system and deployed our BTE beacons in a way, as seen in Figure 9. This greatly decreases the signal intensity of the promotional packages obtained from its beacons just outside of the classrooms by addition of physical barriers, the distance retrieved by the API vendor was up to 4.99 m while there was a retaining wall between its beacon but the tablet, contrasted with the real physical gap was just about 0.5 m.

5.1. BLE Signals and wireless networks

Today's mobile application customer can scan BTE promotional packets for close-by beacons constantly. The output as from API is predicated on the RSSI (signal strength index in dBm) borrowing costs from the packets. A vector with detected distances (d) is the RSSI output. The distance measured (d) between the detected light and the moving portable phone is further determined for each element of the location detected (d), as,

$$\hat{d}_i = \begin{cases} d_i, & \text{if } i = 0 \\ \alpha d_i + (1-\alpha)\,\hat{d}_{i-1} & \text{if } i > 0 \end{cases} \qquad (1)$$

Where I'm heading to € N. The d_i labels the distance measured at the moment i, and d_i is that distance estimated at the range detected at the duration t = I and the length calculated at that time t = I – 1, so α is the weighting factor at 0 < α < 1. The scale of **α** regulates the reactivity of ***d_i*** to mobility. The programme outputs uniformly unique UUIDs, minor and major signal values with minimal defined point (d_i) at times t=i to the remote host in order to find the current location of the mobile unit.

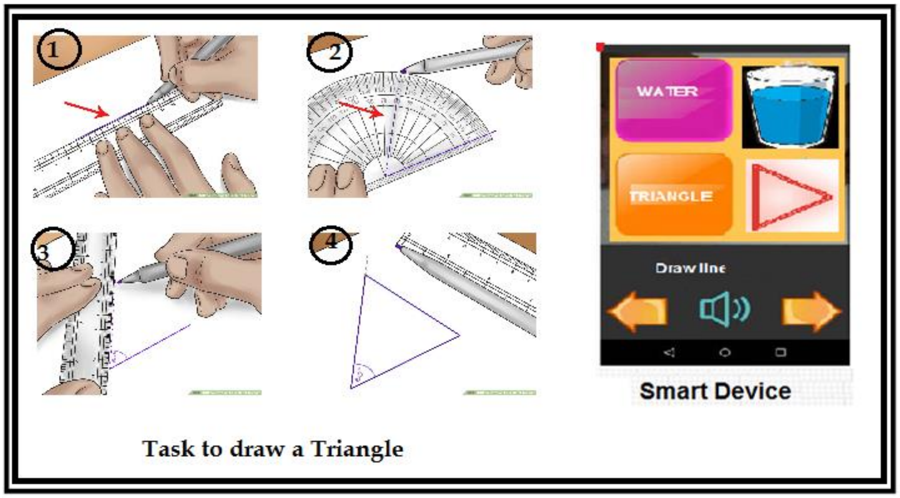

Figure 6. Learning abilities of ID students in the process of drawing pictures.

A variety of deployment variables such as the physical settings of the installation site which influence the precision of beacon ranging and identification. We have therefore undertaken field experiments on-site to evaluate a number of our device operational conditions. We picked three physical areas, such as the hall, the canteen and the screened playground there in school house. We run our application via a hosting machine and moved with either the tablet across the school house. Our application will effectively evaluate each position and correctly have contextual AAC symbols. We also tested the smallest space in the classroom and verified that BLE could be correctly identified in the classroom.

5.2. BLE sensor Configuration and Deployment

In background modeling, the backend software system and database management server contribute. Three database tabs are responsible for background modeling in the program structure; i.e. a position table which records the beacons in a single room within the class room, a routing table for AAC objects and positions and a symbol column for the AAC symbols which store the symbol names of the AAC signals and the URL of its symbol picture. More contextual variables, for example user identities and styles of social interactions, are applied to our background model; suitable tables are also built on the backend servers.

Table 2. Observational distance errors found in subsequent three tests.

Detected distance (meters)	Physical distance (meters)									
	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
Mean	1.15	3.38	4.07	4.97	4.95	7.43	7.03	7.86	8.64	8.02
MAE	0.15	1.38	1.52	1.06	0.71	1.45	0.73	0.90	1.29	2.40
σ	0.09	0.61	0.73	0.83	0.72	0.85	0.56	0.37	0.90	1.15

We carried out experimental testing in classrooms and design a program to determine our patient's BTE-based background recognition capabilities. We have followed the configuration files for the projected 5 Hz beacons with 12dBs power transfer and one second for default duration. Although the speed of walking in many of our target consumers is lower than the normal human pace, the period chosen is optimal to prevent spatial flushing induced by mobility.

We conducted under a standardized approach to topic analysis, a well known methodological technique in psychology and behavioral science. Its characteristics include comprehensive explanations of experiments, health conditions for particular patients and an in-depth study of improvements in results related to treatments manipulated at the level of individual individuals. As a methodology for monitoring evidence-based approaches in therapy and special education, we have taken single topic studies into account. Typical sample size is N = 3 to 8 students in a single topic survey.

5.3. Context Modeling Object Retrieval and models

Our laboratory environment was an enclosed field of approximately 300 m2 in NRI Technology Institute, India. The object of this test is to examine any shifts in distance observed over time. The findings obtained on a regular tablet positioned 2, 5, and 8m far from a beacon, these were common distances between beacons and networking units, are shown in Figure 10. Like the results, distances are observed that fluctuate over time. We are also inspired to measure to find errors only between intervals detected over various physical intervals.

Figure 7. User experimental tests in the sense at canteen during lunch.

This test was meant to measure the error of the gap detected across the real physical variance between a screen and a lamp. The mean, average and averages of the gap from the physical distance is displayed in Table 2. Similar to the published findings, error differences around the real physical distance were recorded. Combining the findings from tests one but two in the deployment setup presented in Figure 11, we could approximate the minimum spatial separation around beacons, in order to facilitate cognitively efficient contextual stimuli.

This test was intended to check our customer's BLE beacon coverage capacity. We conducted our test using two detectors, 10metres apart in the field of vision. At a pace of around 0.5 ms from sensor A to beacon B, the test performer carried a tablet that is around the same speed as with our target customers. We determined the distances measured from the distances observed by choosing α to 0.5. Our customer effectively separated the Bluetooth signals provided by these two beacons and at an acute angle about 5.6m from Beacon A, in which the distances measured for the two detectors were the same.

6. Conclusion

School kids with ID are an inadequately AAC category. While the amount of AAC programs available has increased exponentially, their usage remains a challenge for ID users. Engineers have continued to partner with groups in numerous fields to create technologies to help end-users with various special needs. In this post, we addressed a form of creative in the contextual AAC method focused on BTE. Our success appraisal findings have demonstrated BLE technology's capacity to deliver context-aware AAC services. Moreover, findings from our consumer analysis illustrate the efficacy of the method in developing school children's everyday contact with ID. The paper also opened up a range of unique possibilities for the community with special needs by improving historically standalone AAC systems with BTE network integration and thus future IOT features. Our work has started to resolve school children with ID's unsatisfactory contact needs. Further debates and efforts in context-aware healthcare environments need to be generated such that unique patient audiences can experience the convenience of technical innovations and paradigm changes.

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