Investigation on Data Concurrency for Sensory Fusion in Humanoid Robot

Author: Ashok Kumar Ramadoss*
MCA,MBA,MSc.MatSc, (PhD).
Assistant Professor.
Department of Mechanical engineering,
Coimbatore Institute of Technology,
Coimbatore,
India.Pincode 641 014.
Senior Member UACEE ID: SNM1003553
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*ashokpram@gmail.com, rashokkumar@cit.edu.in

Co-Author : Dr.K.Marimuthu. ME, PhD ,
Associate Professor .
Dept of Mechanical Engineering
Coimbatore Institute of Technology, Coimbatore,
India. Pincode 641 014. Email:
marimuthu@cit.edu.in

Abstract

We believe that a robot should model and recognize a set of grounded responses that are built from knowledge about the nature of the interaction situation, and should also be able to ground responses that are found by semantics-free contingency detection. To carry out Research on Humanoid Robot effectively first in the absence of hardware support then building a Humanoid Robot for achieving data concurency by integerating data by the fusion of sensory datas in the humanoid robot .Multi Sensor fusion Studies for Dynamics and Kinematics thereby achieving Data Concurrency by sensory data integeration by sensor fusion for range detecting by vision and navigation using simulink model and humanoid robot prototype .For this a Simulation Platform could be designed which is easy to operate by using Virtual Reality Modeling Language technology and can be 3D simulated and the simulation results are more intuitive. Within the current framework, we can model and recognize grounded responses as events. As future work, we will investigate how to attribute semantics to ungrounded responses through iterative interactions and finaly by sensor fusion.

In this Research, we could present a simple and reliable approach of creating humanoid robot platform based on the ROBO OS and modeling language using ubunto linux .

Another goal is to investigate the general potential of SFA for using it within sen-sorimotor loops which to our knowledge has not been considered until now. The application of SFA within sensorimotor loops is motivated by pointing out its relation to second-order Volterra filters. Our experiments show that the overall reactivity of the gait pattern increases without any profound loss in stability, and that SFA appears to be suitable for the usage even at such levels of sensorimotor control that are directly involved into motor activity regulation.

This work is concerned on sensitivity analysis of semiautonomy algorithm of humanoid robot to environmental sensors' failures. The construction of the robot, semiautonomy algorithm and used sensors have been described. The algorithm bases on a reactive hybrid approach that merges data from different types of sensors and calculates resulting velocities. This algorithm takes also into account environmental sensors' damage by modifying the behavior of robot in accordance to actual sensors' set state of health. Simulation research using ROBOS/Simulink package and experimental tests' results of semiautonomy algorithm.

The experimental tests were carried out in outdoor conditions. The research and tests were performed for normal environmental sensors' operation and for selected sensors' damage. On that basis, sensitivity of semiautonomy algorithm to selected environmental sensors damage was tested.

Keywords- Contingency/Response detection, Sensory data, Sensor fusion Integration, Vision, Data Concurrency, Sensorimotor, SFA

I. INTRODUCTION

Making Humanoid Robot Research is very challenging. The Cost factor could be optimised for building a humanoid robot prototype it could be better to analysis humanoid robot through simulation before building a humanoid Prototype.

On the basis of the effective simulation the final Protype can be made, for doing this design of the simulation platform is a very essential factor which makes to study the dynamics, kinematics and control method on simulation platform and then validate to prototype model.

So that the adverse financial loss can be avoided on building the model. It has the high order, coupled, variable structure, variable parameter and nonlinear. When a robot understands the semantics of a human's activity in a given context and has a specific expectation over a set of known possible actions, then checking for a contigent response might simply entail matching the human's executed action against the expected action set. This strategy of A contigent behavioural change by a human can occur in one or multiple communication channels. For example, a robot that waves to a human to get his attention may receive the speech of "Hello!" with a simultaneous wave motion as a response. Here , we consider the

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problem of human contingency detect with multimodal sensor data as input when forming our computational model. We validate the multiple cue approach using multimodal data from a turn taking scenario and show that modeling a response using multiple cues and merging them at the appropriate levels leads to improvements at the appropriate levels leads to improvements in accuracy in contingency detection. accuracy in contingency detection. A contingent behavioral change by a human can occur in one or multiple communication channels. Collectively with our previous work , the results in this paper demon-strate that our behavior-change-based contingency detector provides a highly indicative perceptual signal for response detection in both engagement and turn-taking scenarios.

In this paper, we make the following contributions. We present a contingency detection framework that inte-grates multiple cues, each of which models different as-pects of a human's behavior. We extend our prior work, which only uses the visual cues of motion and body pose, to create a more generic contingency detection module. In our proposed framework, the cue response can be modeled as either an eventor a change

II. FRAME WORK PLAN FOR HUMANOID

A. We propose three different levels of sensor integration: the frame level, the module level, and the decision level. We show that for change-based detection, integration of visual cues at the module level outperforms integration at the decision level.
B. We examine the effects of selecting different timing models and referent events. In particular we show how selecting the minimum necessary information referent event, improves detection and requires a smaller amount of data, increasing the tractability of the real-time detection problem.
C. We provide a probabilistic method for measuring the re-liability of visual cues and adaptively integrating those cues based on their reliability.
D. We evaluate our proposed contingency detection frame-work using multimodal data and demonstrate that multi-cue contingency detection is a necessary component for interactions with humans and their multi-modal responses.

III. RELATED WORK TO BE DONE

In a recent paper, we have successfully shown that SFA can handle many kinds of sensory qualities by applying it to abstract visual features, acceleration sensor and motor position data from humanoid robots (Spranger et al., 2009). SFA extracted meaningful components from the multisensory input data stream, which were employed for detecting and classifying postures of humanoid robots.
In this article we demonstrate how SFA can be used to increase the reactivity of a biped gait pattern provided for a humanoid robot platform. The gait pat-tern is neuronally implemented and based on a sensorimotor loop. Although the walking pattern is generally stable, robots tend to fall to the ground when walking on surfaces with a high grip, such as carpets or natural surfaces. Thus, a mechanism to detect when the gait becomes unstable is needed. One of the main problems is that the fraction of time to avoid a collision with the ground or at least alleviate its effects is very short. However, in general both high stability and reactivity cannot be easily achieved at the same time

IV. CALCULATING THE DISSIMILARITY MEASURE

We measure dissimilarity by calculating the ratio of the cross-dissimilarity between V^B and V^A to the self-dissimilarity of V^B . $N(V_i, k)$ denotes the kth nearest neighbor of V_i in V_B . Let E denote the number of dissimilarity evaluations. $CD(V)$ measures the cross-dissimilarity between V^B and V^A in the following equation:

$$CD(V) = \sum_{q=1}^{Q} \sum_{k=1}^{k} \sum_{e=1}^{E} w(VP+q, N(N(VP+q,k),e)), \quad (1)$$

where P is$|V^B|$ and Q is$|V^A|$

$SD(V)$ measures the self-dissimilarity within M_T^B

$$SD(V) = \sum_{q=1}^{Q} \sum_{k=1}^{k} \sum_{e=1}^{E} w(N(VP+q,k), N(N(VP+q,k),e)), \quad (2)$$

The dissimilarity of V, $DS(V)$, is defined as

$$DS(V) = \frac{CD(V)}{SD(V)} \quad (3)$$

$DS(V)$ is the dissimilarity score S for a given V

$$V^B = \{ \nu_t | t \in W_B \} = \{\nu_{l+1}, \nu_{l+2}, \ldots, \nu_{l+P}\}$$

$$V^A = \{ \nu_t | t \in W_A \} = \{\nu_{m+1}, \nu_{m+2}, \ldots, \nu_{m+Q}\}$$

Let $V = V^B \cup V^A$, so $|V| = (P + Q)$. Let V_i denote the ith element of V. The distance matrix DM_X of a cue X is calculated by measuring the pairwise distance between cue elements in V ; DM_X (i, j) describes the distance between cue vectors V_i and V_j using a predefined distance metric for the cue X. We will describe distance metrics for visual cues, motion and body pose.

$$PD(P_1,P_2) = \frac{1}{mK} \sum_{i=1}^{m} \sum_{k=1}^{k} \left\| X^1{}_i - X^2{}_{ik} \right\|_2 \quad (4)$$

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$$+\frac{1}{nK}\sum_{j=1}^{n}\sum_{k=1}^{k}\left\|X^{1}{}_{j}-X^{2}{}_{jk}\right\|_{2} \quad (5)$$

Where X^2_{ik} is the kth nearest neighbor in P_2 to X^1_i and X^1_{jk} the kth nearest neighbor in P_1 to X_j^2.When calculating the distance matrix DM_D of M_T^B and M_T^A, the small value $\in D$ is added to the distance matrix of M_T^B for the same reason of handling noise effects as for the motion cue.

$$P(C\,|\,S_i,S_j) = \frac{P(S_i,S_j\,|\,C)P(C)}{P(S_i.S_j)} \quad (6)$$

$$= \frac{P(S_i\,|\,C)P(S_j\,|\,C)P(C)}{P(S_i,S_j)} \quad (7)$$

$$P(\overline{C}\,|\,S_i,S_j) = \frac{P(S_i,S_j\,|\,\overline{C})P(\overline{C})}{P(S_i,S_j)} \quad (8)$$

$$= \frac{P(S_i\,|\,\overline{C})P(S_j\,|\,\overline{C})P(\overline{C})}{P(S_i,S_j)} \quad (9)$$

$$\frac{P(C\,|\,S_i,S_j)}{P(\overline{C}\,|\,S_i,S_j)} = \frac{P(S_i\,|\,C)P(S_j\,|\,C)P(C)}{P(Si\,|\,\overline{C})P(Sj\,|\,\overline{C})P(\overline{C})} \quad (10)$$

V. RESEARCH METHODOLOGY AND VALIDATION

(a)The sum of the squares of the robot distance to the target

$$E = \sum_{t=1}^{n} e^2{}_t \Delta t \quad (11)$$

where e_t – the robot's distance to the target, N the number of iterations till the robot reaches its target or the simulation ends before the target is reached,

b) standard deviation of the robot's speed

$$S = \sqrt{\sum_{t=1}^{N}(v_t - v_M)^2 / (N-1)} \quad (12)$$

where: v_t – robot's speed, v_M – robot's average speed,

$$\eta(y) := \frac{T}{2\pi}\sqrt{\Delta(y)}, \quad (13)$$

VI . HYPOTHESIS FORMULATION

The first presented simulation has been preformed with all of the robot's sensors working properly. The results of this simulation are presented in Fig. 4-6 and Table 1. They are used as reference for the next simulations, in which influence of selectedsensors' failure is presented.

In Fig. 6 and Table 1 motion trajectories of the robot and quality rates for all simulations. Fig. 7 illustrates robot's linear speeds v_R, its medium value v_M (a) as well as robot's distance e and angle $d\gamma$ to the target (b).

The relation (weighting) between robot's subbehaviors remains constant during the robot's movement. It changes only in case of detection environmental sensors' failure. A performed simulation shown that elaborated method allows omitting obstacles and getting to defined destination point. Robot follows a path with variable speed: the speed is decreased, as movement, the distance to the target is decreasing (Fig.7b).

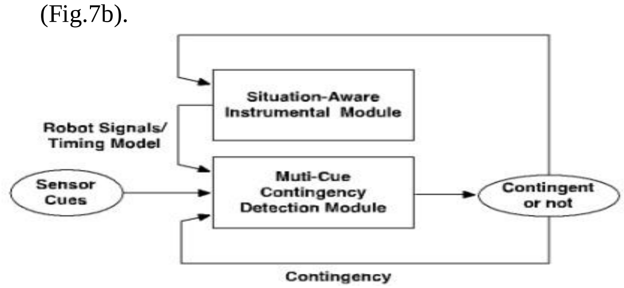


Fig 1. Situation-independent Contingency Detection. Situation specific information, such as robot signals and timing models are parameters of the contingency module

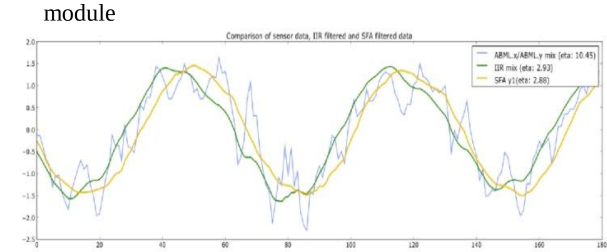


Figure 2. Comparing a weighted sum of the coronal acceleration sensors located at the shoulders to an IIR filtered signal and the slowest component extracted by SFA.

	Frequency (Hz)	Amplitude(db/Hz)
No filter	1.76	-10.71
IIR	1.67	-7.11
SFA	1.47	-8.54

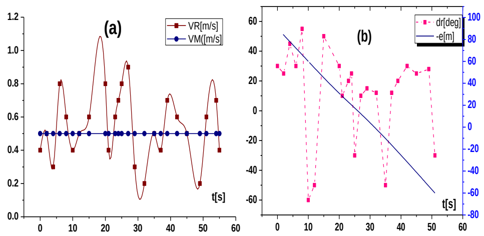
Table 1. Values of quality rates for Simulation

VII. RESPONSE DETECTION

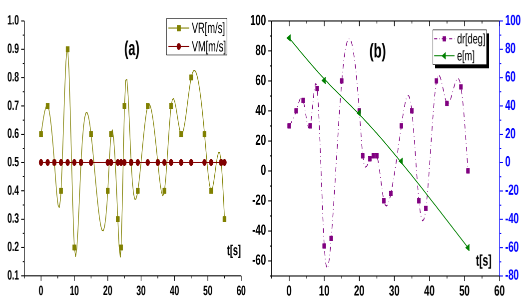
Robot's medium speed v_M (within a time from 0 to T). It should be noted that quality rates (a) – (d) should be minimized whilst (e) should be maximized. In the case the robot cannot reach the target within the assumed time T_{max} = 100 [s], the quality rates s and T reach the value of $+\infty$. Remaining rates reach the values calculated for T_{max}.

VIII. RESULTS

Simulation 1 – all environmental sensors are working properly.



Results of Simulation1, Fig 3 (a),(b)



Results of Simulation 2, Fig 4 (a),(b)

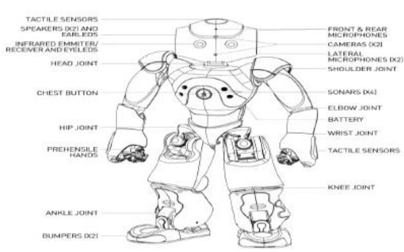


Fig.5 Humanoid Robot Prototype

	S1	S2	S3
E	7317	7681	7287
S	0.131	0.126	0.125
S	23.8	23.6	23.6
T	47.0	50.3	46.1
W	0.51	0.47	0.51

Table 2 Sensistivity Analysis Results

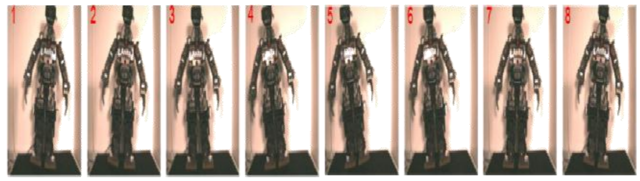


Fig 6. Various Investigations - vision sensitivity Humanoid .

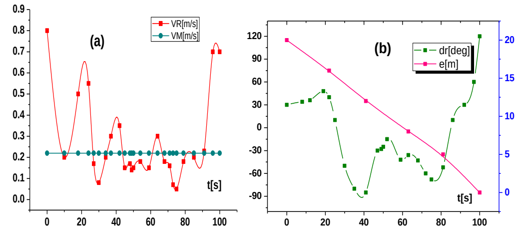
The employed SFA module consists of several subunits: First, the incoming sensory data is embedded in time. The number of tap delays was set to m = 8, i.e., the current and the seven prior sensory data values were passed to the SFA unit, which was empirically evaluated to be a good compromise be-tween computational effort and smoothness of the resulting signal.

In the next step, the result from the time embedding is fed into a linear SFA unit which reduces the dimensionality of the signal to 16 components. Then the 16 components are expanded using a polynomial expansion up to degree 2 and at last passed to a final SFA unit, together forming an SFA(2) unit. Output signals from both the linear and the quadratic SFA units are cut off and bound to [−10.0, 10.0] in order to prevent from very high values caused by the polynomial expansion. Only the first and thus slowest component y_1 of the final SFA unit is considered and used as a driving force for the motor outputs.

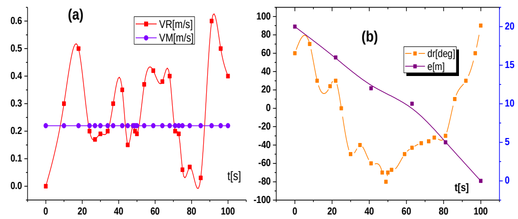
Although we described in (Spranger et al., 2009) that it is possible to obtain very smooth resulting SFA components by the application of several subsequent SFA steps and without time embedding, this method is inappropriate for this task.

IX. FUTURE WORK

Within the current framework, we can model and recognize ground responses as events. As future work, we will investigate how to attribute semantics to ungrounded responses through iterative interactions.



Results of Experiment 1 , Fig 7 (a),(b)



Results of Experiment 2 , Fig 8. (a),(b)

X. DISCUSSIONS

We conducted several experiments with our robots, using the SFA implementation available from the open source Modular Toolkit for Data Processing (MDP) (Zito et al., 2009). In order to compare the obtained signals the η value proposed in (Wiskott and Sejnowski, 2002) was used in equation.

A.Extracted data concurrency for SFA Components

Figure 3 plots data stemming from an extract of an SFA training sequence generated by the unfiltered gait network. The acceleration sensor data mix, the sig-nal obtained by the application of the IIR filter to the acceleration data mix and the slowest component ex-tracted by the SFA module are depicted. All signals were whitened before plotting for better comparabil-ity and calculation of η values. The acceleration data mix's η value being at 10.45 is much higher than the values of the IIR and SFA filtered signals ranging both at about 2.9. It is obvious that the resulting slowest component is highly correlated to both the accelera-tion data mix and to the IIR filtered signal. However, a short delay in the SFA module compared to the other signals issuing from the time delay is observable.

XI. CONCLUSION

In this Research, we could propose a contingency detection framework that integrates data from multiple cues by simulation and thereby implementing in Humanoid experiment.Multimodal sensor data could be gathered from a turn-taking human-robot interaction scenario based on the turn-taking .For contingency detection. It could be showed that using MNI as a referent event provides contingency detectors a more reliable evaluation window. From proposed constrained experiment, it could be an important observation that humanoid response timings and effective integration of cues are important factors to detect contingency. We could believe that this observation could be important to understand other factors situated in more complex and ambiguous interactions. We could believe that our contingency detection module improves a social robot's ability to engage in multimodal interactions with humans then the semantics of the human's behavior are not known to the humanoid Robot. To overcome this limitation, we believe that a robot should model and recognize a set of **grounded responses** that are built from knowledge about the nature of the interaction situation, and should also be able to ground responses that are found by semantics-free contingency detection.we have investigated how to attribute semantics to **ungrounded responses** through iterative current framework, we can model and recognize grounded responses as events. In this Research, we could present a simple and reliable approach of creating humanoid robot platform based on the SimMechanics and Virutal Reality Model Language using Robo Os This approach could be low cost, easy to operate. Also, it could have a good scalability. Therefore, put the robot platform into the different virtual environment, different studies could be conducted, such as ,walking control, arms coordinated operation, multi-robot coordination manipulation.

REFERENCES

[1]. Yang Yu-biao, He Han-wu. A study of VRML-JAVA Based Robot Motion Simulation. *MECHANICAL SCIENCE AND TECHNOLOGY*; 2004, 23(1), p. 120–126

[2] .Pitsch K, Kuzuoka H, Suzuki Y, Sussenbach L, Luff P, Heath C (2009) The first five seconds: Contingent stepwise entry into an interaction as a means to secure sustained engagement. In: IEEE international symposium on robot and human interactive communication (ROMAN)

[3]. Feature fusion for 3D hand gesture recognition by learning a shared hidden space. Jun Cheng J. et al. Pattern Recognition Letters 33 (2012) 476–484 , Elsevier . Can Xie a,b, Wei Bian a,b,c, Dacheng Tao c, Shenzhen Institutes of advanced Technology, Chinese Academy of Sciences, China b The Chinese University of Hong Kong c Centre for Quantum Computation and Intelligent Systems, Faculty of Engineering and Information Technology, University of Technology, Sydney Broadway NSW 2007, Australia.

[4]. Lee J, Kiser J, Bobick A, Thomaz A (2011) Vision-based contingency detection. In: ACM/IEEE international conference on human-robot interaction (HRI).

[5].Inverse Kinematics of Human Arm Based on Multisensor Data Integration. Mihelj (B) et al J Intell Robot Syst (2006) 47: 139–153 Elsevier ,Faculty of Electrical Engineering, University of Ljubljana . 25.