Implementation of Matching Stimulus-Movement Experiment on a Humanoid Robot

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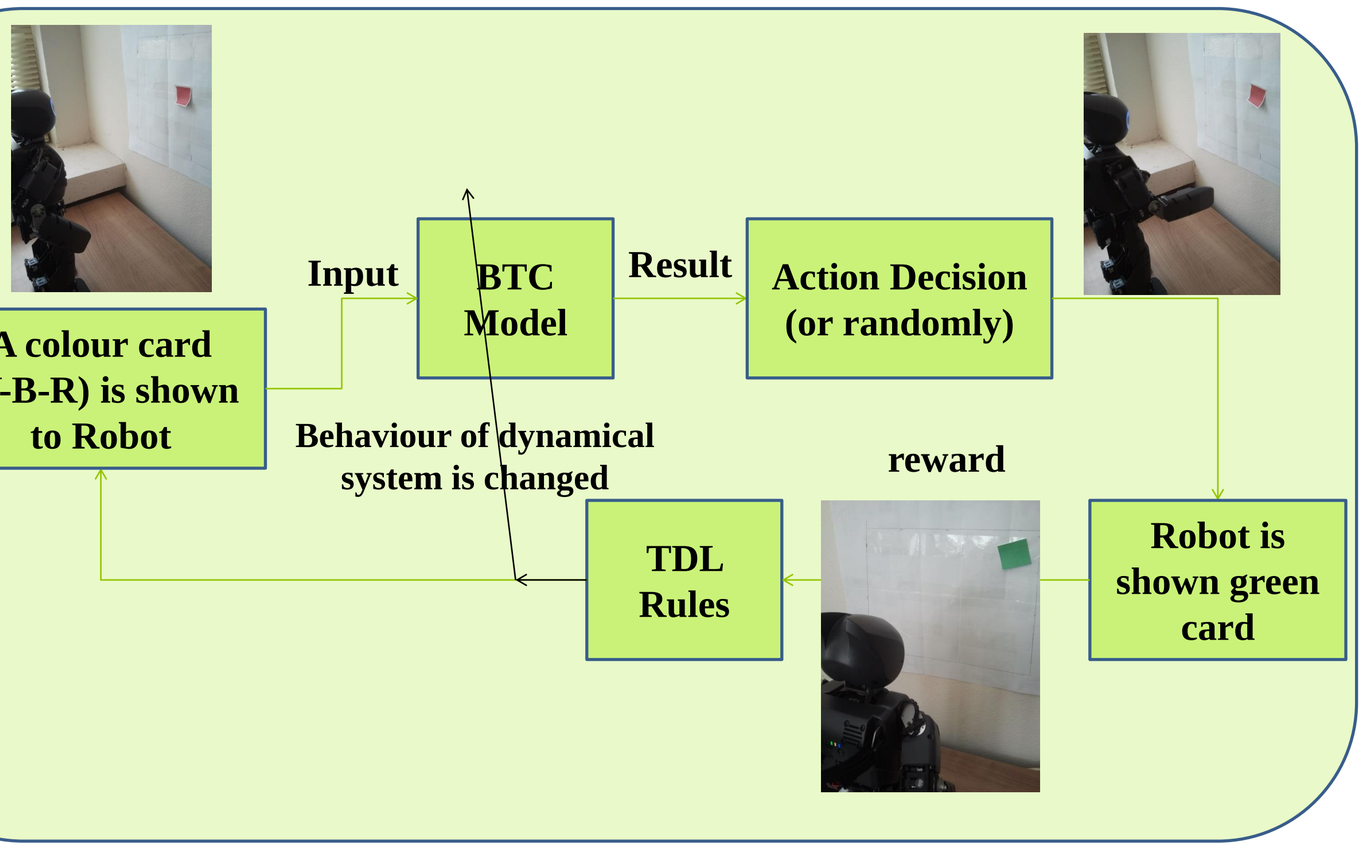
ABSTRACT

In this study, we implemented a working memory task on a humanoid robot, Darwin-Op, using Basal ganglia-Thalamus-Cortex action selection model and temporal difference learning rules [2]. The task is structured upon matching the stimulus with a predefined action. When a colour card (R-Y-B) is shown to robot, it is urged to select an action. If the right action is selected, a reward is given to reinforce the robot 's right action. This reward generates an expectation error and this error updates the parameters of action selection model. After matching a stimulus and action, in order to force the robot to adapt to a new action, nothing is given to right action. This urges the robot to rearrange the connection between the stimulus and the action.



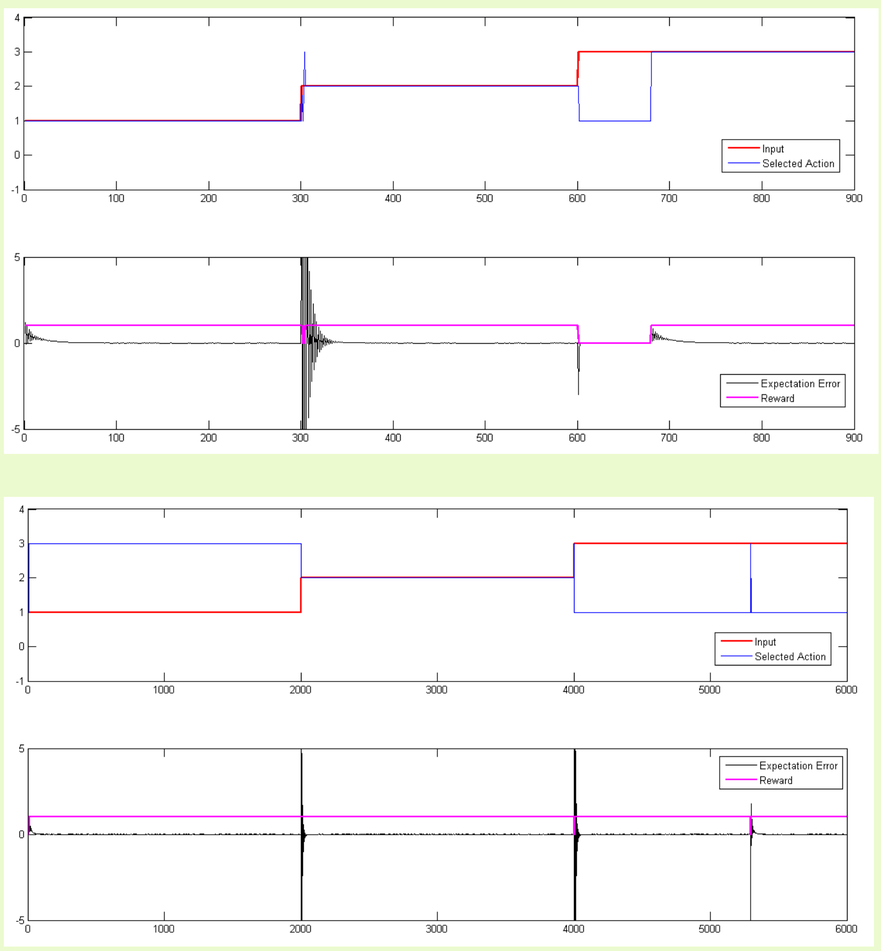
BTC Model Equations

$$S(k) = WcI(k)$$
$$Ctx(k+1) = f(\lambda Ctx(k) + Thl(k) + S(k))$$
$$Str(k+1) = Wrf\big(Ctx(k)\big)$$
$$GPe(k+1) = f(-Str(k))$$
$$Stn(k+1) = f(Ctx(k) - GPe(k))$$
$$GPi(k+1) = f(Stn(k) - Str(k))$$
$$Thl(k+1) = f(Ctx(k) - GPi(k))$$

Temporal Difference Learning Rules

$$V(k) = Wv(k)I(k)$$
$$\delta c(k) = r_c + \mu V(k-1) - V(k)$$
$$Wv(k+1) = Wv(k) + \eta_c \delta c(k) I(k)$$
$$Wc(k+1) = Wc(k) + \eta_c \delta c(k) Ctx(k) I(k)$$
$$Wr(k+1) = Wr(k) + \eta_c \delta c(k) Ctx(k) Str(k)$$

MATLAB Simulations



1st action ⇔ 1st stimulus
2nd action ⇔ 2nd stimulus
3rd action ⇔ 3rd stimulus

$$Wc=\begin{bmatrix}8.68 & -8.11 & -0.56\\ 0.11 & 23.14 & -2.55\\ 0.11 & -7.5 & 9.14\end{bmatrix}$$

$$Wr1=\begin{bmatrix}0.8275\\ 0.9986\\ 1\end{bmatrix}\ Wr2=\begin{bmatrix}1\\ 0.6466\\ 1\end{bmatrix}\ Wr3=\begin{bmatrix}0.9108\\ 0.9098\\ -0.0556\end{bmatrix}$$

1st action ⇔ 3rd stimulus
2nd action ⇔ 2nd stimulus
3rd action ⇔ 1st stimulus

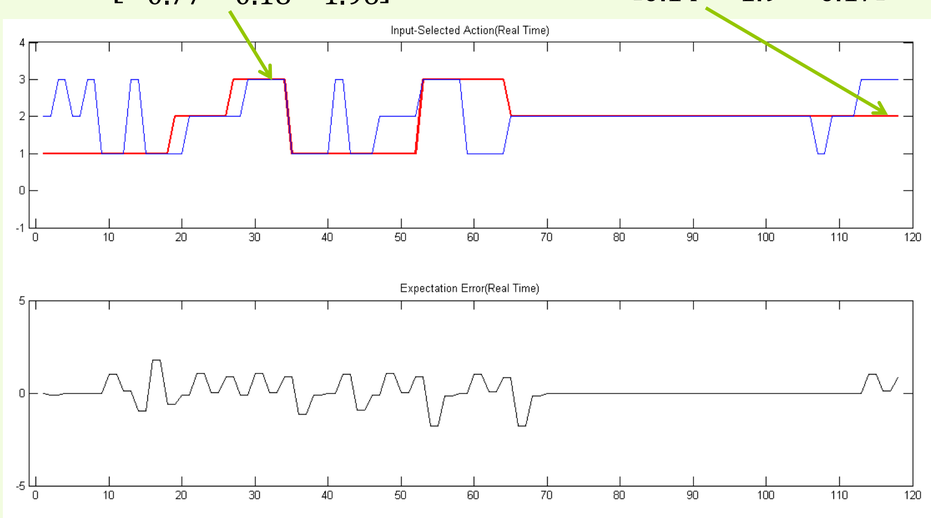
$$Wc=\begin{bmatrix}-3.06 & -8.11 & 6.38\\ -1.19 & 1.88 & -11.6\\ 0.3 & -7.51 & -18.6\end{bmatrix}$$

$$Wr1=\begin{bmatrix}1\\ 1\\ 0.5497\end{bmatrix}\ Wr2=\begin{bmatrix}1\\ 0.5167\\ 1\end{bmatrix}\ Wr3=\begin{bmatrix}0.5498\\ 1\\ 1\end{bmatrix}$$

Bifurcation Parameters : Wc & Wr

Real Time Results

$$Wc_{first}=\begin{bmatrix}2.2 & 0.05 & 0.18\\ 0.09 & 1.97 & 0.03\\ -0.77 & 0.18 & 1.96\end{bmatrix}\qquad Wc_{second}=\begin{bmatrix}0.15 & 0.05 & 1.91\\ 1.87 & 0.17 & 0.03\\ 0.14 & 1.9 & 0.17\end{bmatrix}$$



Conclusion

Humanoid robot is trained to match an action successfully with a stimulus in real-time. It can rearrange the association it has set up between a stimulus and an action to rebuild a connection between the stimulus and a new action. All this is rendered possible with a dynamical system that has bifurcation parameter changing the desired fixed point (action). Reinforcing an association causes harder suppressing of the learnt connection. By showing the compatibility of the model and robot, we can further implement SNN model for action selection and pattern recognation module for realizing more complex tasks.

References

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