嗨！我是路易斯，陪你一起學習成長的好朋友

Hi! I Am Louis and Very Happy Being with You. Let's Grow Up and Learn Together

APPLICATION GROUP A19-119

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研究領域

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研究領域

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作品介紹

本企劃提出能自主學習成長的幼兒型機器人並取名為路易斯。首先，使用全域最佳引導式人工蜂群演算法來解決與機器人設計相關的優化問題，並加入基因演算法的概念協助改良人工蜂群演算法以提升設計速率。在確立整個機器人的硬體結構後，其次探討動作學習之發展過程。同樣使用全域最佳引導式人工蜂群演算法，針對幼童最常使用的四種動作解決其優化問題，四種動作分別為爬行、蹲、站以及行走。具備四大動作之能力後，將幼兒探索應用之問題轉化為一行為規劃地圖，並使用增強式學習法來解決該地圖問題。為使幼兒型人形機器人走得平穩，本企劃以 Fuzzy Double Deep Q-learning Network 並搭配 IMU 與腳底壓力感測器，學習如何使步態適應不同地形，達到動態即時控制的效果。本企劃將控制系統建立在以 Linux 作業系統為基礎之平台上，並將兩方向重心值與兩方向加速度值透過適應性模糊控制理論加以分析，再根據已分析之資料，訓練 Double Q 深度神經網路，使其能適當地表現訓練資料間的非線性關係且同時避免過擬合現象。

接著使用非監督式學習架構搭配自我探索策略，讓嬰兒機器人能在無人環境中自主探索環境、與物件互動，並在探索過程中學習成長。本企劃提出改良式深度分群演算法，讓機器人學習玩具的形狀概念。路易斯備有深度攝影機與一雙四軸機械手臂，用以抓取與探索物品。在學習物品概念階段，機器人會主動探索物品的各個視角，以變形自動編碼器提取視覺特徵，使物體的外觀輪廓與變形流場之特徵相互獨立，並以深度分群網路針對物體的外觀輪廓特徵進行分群。此架構相較原始深度分群網路，能去除視覺因探索過程中物體姿態不同而造成的影像轉換變形，更精準地學習到物體本身外觀的概念，並以實驗證實改良後的分群網路有較高的正確率。除此之外，為證實所研製人形機器人能利用已學習的物件辨別概念，更進一步學習高階知識，本企劃以卷積神經網路學習智力測驗中序列式圖形邏輯推理之題目，使機器人學習網格中物件在時間順序上的關係，並準確預測下個時間點網格中物件的位置，實現機器人累積經驗與自主成長的可能性。

實驗結果顯示，此幼兒型機器人的開發設計，能成功做出不同動作，並能學習各個基礎動作之間的轉換，在行走過程中也能自我調適、平衡，在自我探索與學習的任務中亦能正確地辨認出四種不同形狀的玩具方塊。

圖 1．Louis

ABSTRACT

This project designs and implements a toddler-sized humanoid robot, Louis, which possesses self-learning capability. At first, this project employs Gbest-guided ABC algorithm to solve mechanism optimization problem and applies GA crossover concept into Gbest-guided ABC to improve the efficiency. After establishing the entire robot architecture, the next step is to study the processes of motion learning. We also exploit Gbest-guided ABC to solve optimization problems of four most commonly used motions, crawling, squatting, standing up and walking. Once Louis possesses these four motion abilities, the problem of exploration transform for behavior planning map is then established by Q-learning. In order to improve the stability of gait pattern, we propose Fuzzy Double Deep Q-learning Network (FDDQN) combined with IMU and force sensors to make Louis walk on different terrains in real-time control cases. This project builds the control system based on Linux operating systems. The value of center of pressure (CoP) and acceleration are analyzed by ANFIS. One can use these data to train DDQN. The structure of the proposed neural network is composed of four layers and model is properly chosen to avoid overfitting.

In the next stage, an unsupervised learning architecture with self-exploration is presented to make our robot interact with environment and grow up in the exploration process. The cognitive learning system with deep deformed embedding clustering (DDEC) that makes robot learn the concept of toys is also proposed in this project. Louis equips RGB-D camera to capture the information about surroundings and has dual arm with four degrees of freedom to grasp the objects. In active learning phase, he could grasp the unknown object and move both his arms and head to explore the different views of the object.

Once the exploration has been done, the deforming auto-encoder (DAE) is adopted to learn the deformed embedding of each object, and DDEC utilizes the disentangled embedding to further learn how to distinguish the category of objects in unsupervised manner. In addition, to ensure that Louis can put learnt knowledge in practice, the sequential reasoning task inspired by diagrammatic reasoning tests is achieved by learnt concept and reasoning network.

The experimental results illustrate that our designed and implemented toddler-sized humanoid robot can complete different motions successfully and understand the transformation between each motion. Louis can also adjust and balance its gait pattern during walking. In the mission of self-exploration, he also can recognize four toy cubes with different shapes.