الجمهورية الشعبية الديمقراطية الجزائرية
République Algérienne Démocratique et Populaire
وزارة التعليم العالي والبحث العلمي
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique

المدرسة العليا للإعلام الآلي - 08 ماي 1945 – بسيدي بلعباس
Ecole Supérieure en Informatique
-08 Mai 1945- Sidi Bel Abbes

MEMOIRE

En Vue de l'obtention du diplôme de **Master**

Filière : **Informatique**

Spécialité : **System Information et Web (SIW)**

Federated Graph Neural Network Techniques

for Decentralized Autonomous Robots

Data Fusion

Présenté par **:**

- Mlle. *TALBI Feryal Batoul*

Soutenu le : **04/07/2023** Devant le jury composé de :

- Mme DIF Nassima	Président
- Mme BOUSMAHA Rabab	Examinateur
- M.MALKI Mimoun (ESI SBA)	Encadreur
- M. DUPUIS Yohan (Lineact)	Encadreur
- M.OUCHANI Samir (Lineact)	Encadreur

Année Universitaire : 2022 / 2023

Dedication

I would like to dedicate this work to my family, whose unwavering support and encouragement have been the foundation of my academic journey. Their love, belief in my abilities, and constant motivation have inspired me to overcome challenges and pursue excellence in my studies. I am grateful for their sacrifices and for always being by my side, cheering me on every step of the way.

To my friends ***Imene***, ***Sanaa***, ***Souhila*** *and,* ***Walae*** *. Your friendship has made this experience more enjoyable and memorable. Your presence during the highs and lows has been a true blessing, and I am grateful for the moments we have shared together. Your words of encouragement and uplifting conversations have kept me motivated and focused. I am truly fortunate to have such amazing friends in my life, and I cherish the memories we have created together. This achievement is as much yours as it is mine, and I am grateful for your support. Thank you for being there every step of the way.*

Lastly, I would like to acknowledge the contributions of all the participants and individuals who have generously shared their time, knowledge, and resources for the success of this research. Without their cooperation and support, this project would not have been possible.

To all those mentioned above and to anyone else who has been part of my journey, I offer my deepest gratitude and appreciation. This achievement is a reflection of our collective efforts, and I am honored to have had such remarkable individuals in my life.

Thank you.

”

Feriel

Ackowledgments

First and foremost, I would like to express my heartfelt gratitude to Allah for granting me strength, perseverance, and guidance throughout this journey. Without His blessings and mercy, I would not have been able to achieve this milestone.

I am immensely grateful to Lineact CESI Compus Aix en Provence for providing me with the opportunity to conduct my research within their esteemed institution. The state-of-the-art facilities, resources, and collaborative environment have been instrumental in the successful completion of this project.

I am indebted to my advisors, Mr.OUCHANI Samir, Mr.DUPUIS Yohan, and Mr.Mimoun Malki, for their unwavering support, patience, and expertise. Their guidance, insightful feedback, and encouragement have been invaluable in shaping my research and enhancing my skills. I am grateful for their mentorship and the time they dedicated to nurturing my academic growth.

I would like to extend my sincere appreciation to all the professors, researchers, and staff members of the ESI SBA. Their dedication to excellence, passion for knowledge sharing, and willingness to provide assistance and support have been pivotal in my academic journey. Their expertise and guidance have helped me navigate through challenges and broaden my understanding of the field.

I am grateful to the administrative staff and technical support team for their assistance and professionalism. Their prompt response, efficient organization of resources, and seamless coordination have greatly facilitated the smooth progress of my project. I extend my heartfelt thanks for their contributions behind the scenes.

I would also like to acknowledge the contributions of my fellow students and colleagues. Their camaraderie, intellectual discussions, and collaborative spirit have created an enriching learning environment. I am thankful for their friendship and the shared experiences that have made this journey more enjoyable.

Last but certainly not least, I would like to express my deepest gratitude to my family and friends. Their support, encouragement, and understanding have been a constant source of motivation and strength. Their belief in my abilities and their sacrifices have

propelled me forward, and I am truly blessed to have them in my life.

To everyone mentioned above and to those who have supported me in ways beyond words, I offer my heartfelt thanks. Your contributions, guidance, and encouragement have played a significant role in my academic achievements. I am honored and grateful for the opportunities I have been given, and I hope to make you proud in all my future endeavors.

Résumé

Ce travail de recherche porte sur l'apprentissage fédéré appliqué aux réseaux neuronaux graphiques pour la détection d'objets par des robots autonomes. L'apprentissage fédéré est une technique innovante qui permet d'entraîner un modèle partagé entre plusieurs entités sans avoir besoin de partager leurs données originales, garantissant ainsi la confidentialité et la sécurité des informations. Cette technique est particulièrement adaptée aux scénarios où les données sont réparties entre plusieurs robots ou appareils, ce qui pose des défis en termes d'accès centralisé aux données, de bande passante de communication et d'hétérogénéité des données. Les réseaux neuronaux graphiques sont des outils puissants capables d'apprendre à partir de données structurées sous forme de graphes, capturant ainsi les relations complexes et les dépendances entre les nœuds et les arêtes d'un graphe.

Pour réaliser ce travail, j'ai commencé par effectuer une revue de la littérature afin d'explorer les différentes approches existantes qui visent à surmonter les limitations mentionnées ci-dessus. J'ai constaté qu'il existe un nombre limité d'articles traitant spécifiquement de ce sujet.

Mots Clés :

Apprentissage fédéré, Réseau neuronal graphique,réseau neuronal graphique fédéré, Agent robotique,fusion de données,systèmes robotiques, Sécurité.

Abstract

This research work focuses on federated learning applied to graph neural networks for object detection by autonomous robots. Federated learning is an innovative technique that allows training a shared model among multiple entities without having to share their original data, thus ensuring the confidentiality and security of information. This technique is particularly suitable for scenarios where data is distributed among multiple robots or devices, which poses challenges in terms of centralized access to data, communication bandwidth, and data heterogeneity. Graph neural networks are powerful tools that can learn from data structured as graphs, capturing complex relationships and dependencies between nodes and edges of a graph.

To carry out this work, I started by conducting a literature review to explore the different existing approaches that aim to overcome the limitations mentioned above. I found that there are a limited number of articles specifically addressing this topic.

Keywords : Federated Learning, Graph Neural Network, Federated Graph Neural Network, Robot Agent, Data Fusion, Robotic Systems, Security.

ملخص

هذا العمل البحثي يركز على التعلم الفيدرالي المطبق على الشبكات العصبية الرسومية للكشف عن الأشياء بواسطة الروبوتات المستقلة. التعلم الفيدرالي هو تقنية مبتكرة تسمح بتدريب نموذج مشترك بين كيانات متعددة دون الحاجة إلى مشاركة بياناتها الأصلية ، مما يضمن سرية وأمان المعلومات.هذه التقنية مناسبة بشكل خاص للسيناريوهات التي يتم فيها توزيع البيانات بين روبوتات أو أجهزة متعددة ، مما يطرح تحديات من حيث الوصول المركزي إلى البيانات وعرض النطاق الترددي للاتصال وتنوع البيانات.الشبكات العصبية الرسومية هي أدوات قوية قادرة على التعلم من البيانات المنظمة على شكل رسوم بيانية ، مما يلتقط العلاقات المعقدة والاعتماديات بين العقد والحواف للرسم البياني. لإجراء هذا العمل ، بدأت بإجراء مراجعة للأدب لاستكشاف المقاربات المختلفة الموجودة التي تهدف إلى التغلب على القيود المذكورة أعلاه. وجدت أن هناك عددًا محدودًا من المقالات التي تتناول هذا الموضوع على وجه التحديد.

وكيل الروبوت، دمج البيانات ، نقل التعلم ، التعلم الإتحادي ، شبكة عصبية رسومية ، شبكة عصبية رسومية متحدة ،أنظمة الروبوتية , الأمن.

List of abbreviations and acronyms

GNN	*Graph neural network*
GCN	*Graph convlotional Network*
GAT	*Graph Attention Network*
GraphSage	*Graph Sampling and Aggregating*
FL	*Federated Learning*
FedAvg	*Federated Averaging*
MPAG	*Multi-Party Gradient Aggregation*
MPA	*Multi-Party Averaging*
FedProx	*Federated Proximal Algorithm*
FedGNN	*Federated Graph Neural network*
DARs	*Decentralized Autonomous Robots*
Non-IID	*Non-Independent and Identically Distributed*