Primitive thoughts on Self-aware collective areal transportation - version 0.1

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1 Abstract

(The abstract should be changed) This proposal takes a collective self-aware approach to prove that semantic-awareness improves better decision making with regard to maintaining homeostatic state of swarms who should transport a load. Self-awareness which is considered here as the ability of an Intelligent Agent to recognize abnormality from its initial knowledge and build, memorize and retrieve new dynamic models out of high abnormalities for further use. Semantic-awareness in this proposal is equal to Level 1: Understanding the dynamic models other agents are reviewing now and Level 2. Understanding the difference between same models appearing in different contact (i.e previous model and future model). This proposal plans to prove that the higher the level of semantic-awareness is, the better collective behavior is achieved in a local communication scheme in which agents are allowed only to communicate with neighboring agents. That is, better generative/descriminative and abnormality detection models will be generated which will result in emergence of improved collective behavior.

2 Introduction

3 Related areas

Discreeting Generalized state space

Force Field analysis

4 Motivation

Scientific

- Does local semantic communications, improve existing collective behavior?

5 Objectives

Short term Improving the state of the art by any means

Long term Developing a Bayesian based, self-aware framework such that it can

- Make a distinction between the abnormalities raised from a new experience or those from minor disturbances (Disturbance rejection)

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6 Problems which should be solved

- Formation control

- Path planning

- Trajectory tracking

- Disturbance rejection

- Collision avoidance

- State estimation

  - Sensors
  - Localization (vectors denoting)
    * Relative to the start point
    * Relative to neighboring agent

7 Possible ways to improve the state of the art

- Swarm intelligence

  - Semantic, local communication
  - Training a model to map locally emergent individual behavior to collective behavior
    * Individual behavior is modeled in papers such as Kanapram et al. (2020) to collective behaviors described in Baydoun et al. (2019)

- Taking a leader-less or leader variant approach

  - Leader will be changed according some kind of privileged such as its closeness to the destination or being positioned such that better degree of data(information) access is provided

From sensing to building words of individual quasi-constant motions such as Kanapram et al. (2020) to collective behavior describe with languages such as Baydoun et al. (2019)

8   Related work and state of the art

Collective adaptive systems

> **Collective object transportation**

> **Existing object transportation with multi drone systems**   Jackson et al. (2020)

Existing drone swarm navigation models in tight spaces   Soria et al. (2020)

Swarm flocking   Vasarhelyi et al. (2014)

Swarm collective behavior through local communication

Self-organizing swarms

> **Self-organizing drones**

Dynamic systems modeling

> **Discretization of continuous features**

> **Dynamic Bayesian Models**

Force field analysis

Semantics

> **Semantics in dynamic systems**

> **Dynamic semantics**   Dynamic semantics is a perspective on natural language semantics that emphasizes the growth of information in time.

> **In action sequences**

> **in natural language**

9   Methodology

From individual perception to collective behavior   : The methodology must cover from the simplest

- Individual perception of environmental data

- individual decision making

- creating individual generative models

- creating generative interaction model for each triples of agents with consecutive rankings (agents are aware of existence of the behind and front agents)

- messaging to neighbors through individual generative models

- creating individual descriminative model in which a messaged individual generative model and the rank of the sender may cause a decision and an action

- Collective behavior

Overview   The experiment takes a collective self-aware approach in the sense that it will be first trained by an initial generative model for a reference task and then new generative and descriminative models will be generated from the data presenting the observed abnormality. The modeling starts from initial modeling of collective movements of a straight flight from one point to another and then introducing the initial flight path with obstacles such as tight flight corridors which may need a collective maneuver or column avoidance which needs a single maneuver to avoid the obstacle. From these new experiences, new models should be generated and through neighboring interactions other agents should learn to decide a reaction according to the communication. The goal of this proposal is to prove that if such model messages is transmitted locally but contextually, then some improvments will be observed in comparison to the base models.

9.1   Homeostasis state hierarchy

The goal of self-awareness is to maintain homeostasis of a system. In this proposal, homeostatic state is the generalized state in which the dynamic systems has the highest survival chance and comes at the following levels in this proposal

1. Trying to keep individual abnormality signal possible

2. Avoid individual collision

3. avoid load collision

4. Trying to keep the collective abnormality signals minimum according to the currently practicing generative model

5. Returning back from the current interaction model to the reference interaction model (a regular, 2d convex) as soon as possible which might be one of the following tasks

9.2   Generative models

Two generative models should be considered. One which defines

Interaction model   The necessary changes in the course of orientation vector that each two consequent ranked agents should keep according to perform each maneuver such as those in the scenarios in Section

Individual model   The trajectory which each individual agent is supposed mov

Discretization   As a further phase, to avoid computational complexity, such models should be learned by dividing the environment to discreet regions in which mutual relation dynamism is approximately constant and such models should be trained for consecutively ranked agents and not between all agents.

9.3   Discriminative models

The models which are responsible to attribute a sequence of observations with the best fitting generative model.

For collective behavior

For individual behavior

9.4   Abnormality detection

Feature selection

Sources of abnormality detection

9.5   Generative/Descriminative Model creation

After abnormality detection, the sequence of data which represents the abnormality should be used for training a dynamic generative model.

9.6   Semantic awareness

Such awareness should bring such an ability to an agent that when abnormality occurs in the course meaningful (discretized) generalized state space, then it is noticeable by other agents

- To build a language formed of verbs and adverbs to describe quasi static motion states of agents (name awareness is like what multi camera awareness)

Semantic means the signification relationship between a sign and a signified. Accordingly,semantic-awareness is the ability to correspond signs to signified entities. This ability embodies in

- Cause(sign)-effect awareness (Models mostly by Bayesian inference/reasoning)

- A sign can refer to signified entities such as actions, entities etc

such ability in an artificial intelligent agent must arise

- reactions

which may ultimately result in reactions

- improvement in homeostatic situation of an agent

So this is the process

1. emergence of a sign

2. corresponding it to a signified

3. action

Construction of a language   Discreetizing generalized state space such that from (some) **New composition of different segments** new semantic(signified entities) arises. If the no dicreetized segments composition arises any meaning, then no language is built. these meanings may refer to

- Existing signified entities (maybe in the generalized state space)

- A semantic piece of collection behavior 9.6.2

Is the matter of building a language which is understandable by all agents. Mostly, the alphabet of such language is based on discretizing the generalized state space (by clustering methods such as Fiser et al. (2013), Kohonen (2001)) such that motion remains relatively constant. Generalized space can be used

9.6.1 Language to describe dynamism of individual generalized state spaces (individual semantic awareness)

Kanapram et al. (2019) offers an exammplary method is to cluster the data for each time dervitave order of generalized state space and uses the centroids of each cluster as the representative of that cluster. These representatives form the alphabet with which words representing different generalized state spaces can be introduced by different composition of such alphabets i.e, in a moving object different positions, velocities and alterations are clustered into different classes and different composition of centroids of a position class, a velocity class and an alteration class builds a word. Such word could be transmitted to neighboring nodes to describe a reviewed, practicing or predictable experience.

9.6.2 Language to describe dynamism of interaction (collective semantic)

Language 1 The same language as described in Section 9.6.1, this time for the dynamism of the interaction between agents to perform different maneuvers.

Language 2 Baydoun et al. (2019) suggests a language in which alphabets are formed of clustered regions in generalized state spaces of individual dynamic agents while coincidence of such regions by all agents in the network form the vocabulary.

9.6.3 From individual behavior to collective behavior

Deals with the problem of contribution of local individual behavior in emergence of collective semantics.

9.6.4 Synchrony and diachrony

Whether the vocabulary is describing individual or collective agents behavior, in each language previously experienced generalized state can represent the past, currently experiencing generalized state can represent now and predicted generlized state can represent the future tense along the diachrony (horizontal) of the forming language. On the other hand, the distance between classes from which such words come from, can model the synchrony of the language.

9.6.5 The question

Now the question is how such semantic awareness improves

- Abnormality detection

- New generative model creation

- Discriminate between generative models

- Improving decision making and control

For example if a drone receives a message with a different sematic vector, how should it react to it with its actuators? **But the most important thing is that, does semantic awareness improves performance of the discriminative models by which the agent chooses the best matching generative model according its observation?** In a semantic-aware multi agent system, observation is composed of

- the data derived from its exteroceptive and proprioceptive sensors

- the semantic messages it receives other (in this case neighboring) agents.

- The rank of the sender agent

One study possibility is that which sequence of individual motion (words) means (is the evidence) for which collective word (behavior)

9.7   Force-field analysis

Force-field analysis is a development in social science. It provides a framework for looking at the factors (forces) that influence a situation, originally social situations. It looks at forces that are either driving movement toward a goal (helping forces) or blocking movement toward a goal (hindering forces).See footnote reference Wikipedia (2020) Campo et al. (2017)

9.8   Neighboring agents and Ranking

The one which is closer to the destination will be ranked lower and the ranking starts from 1. The leader is rank 1. The leader is rank one.

9.9   Communication

Communication rules   The goal of the rules are to define a notion of neighborhoodness for the agents.

- No agent can transmit the generative models from other agents to the neighboring agent.

- Messages can be made of one generative model and the senders rank or more than one (for distributional semantics)

- Messages can only be transmitted to neighboring ranked nodes when the generative model an agent is practicing changes.

9.10   Sensors

Exteroceptive

- Environment

Start point

P_1

5

3   4

1

2

destination
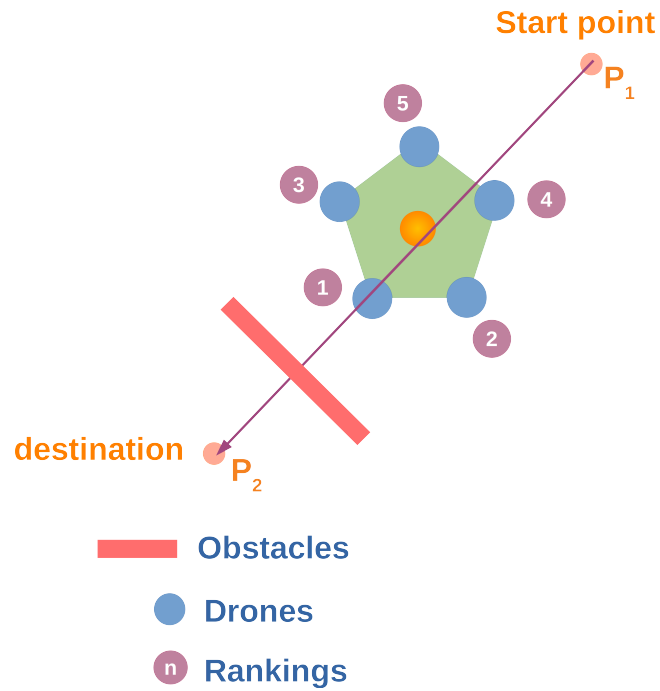
P_2

Obstacles

Drones

n **Rankings**

Figure 1: Closer agents to the destination take the lead. If destination of two agents is measured to some degree of tolerance equal, then random ranks will be assigned. Semantic stated interaction is only allowed between consecutive neighboring ranks.

- – Lidar
- – Stereo camera
- From neighboring agents

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Proprioceptive

- Gyroscope: For measuring pitch, role, yaw

- IMU: Inertial measurement unit

Heterogeneity   Heterogeneity of the sensors which plays the heterogeneity for the whole system will be sought in deployement of different sensors installed independently on different agents.

Contextuality   Discusses the architecture along which data should be formed to develop better descriminative and generative models.

- Active self

- Passive self

Multi-sensory approach / Fusion

Feature selection   Features should be selected such that they capture the best abnormality.

Feature selection for generative and discriminative models   Choosing the best set of features which captures metrics such as abnormality

Sensor precision

9.11   Decision making and control

- A model to convert abnormality signals to decisions for actuators

  - – To return back the system to the best fitting, existing generative model by simultaneously making decisions that minimize the deviations from that model
  - – Continuously trying to return back to the reference generative model this reference model defines the homeostasis to which the whole system tries to return
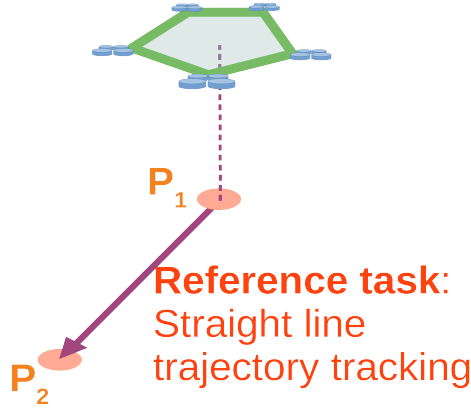
Figure 2: Straight line trajectory tracking to destination

10   Experimental setup / Scenarios

It must start by detection abnormal communication of changing practicing models and vocabulary whuch describes the discretized generalized state space. This section, contains scenarios for which DBN models should be trained. Having these models trained, then whatever solution is decided, then it should improve

- Predictive model selection

- Generating predictive models

- Decision making to decrease abnormality rate (the difference between the state prediction of practicing models and state observation) which must result in better trajectory tracking models

Each scenario, is in fact, a predictive model.

10.1   Base scenarios

Reference scenario, Straight line trajectory tracking to destination

Scenario: Horizontal obstacle avoidance

Scenario: Vertical obstacle avoidance

Scenario: Turning

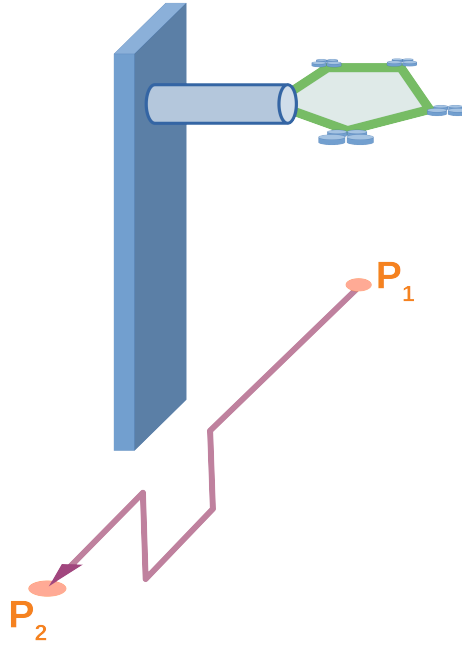**Scenario: Altogether, Motion planning and collision avoidance to maintain homeostasis**   See Fig 6

Figure 3: Collective horizontal obstacle avoidance

11   Papers

Conferences

Journals

- Journal of advanced transportation [1]

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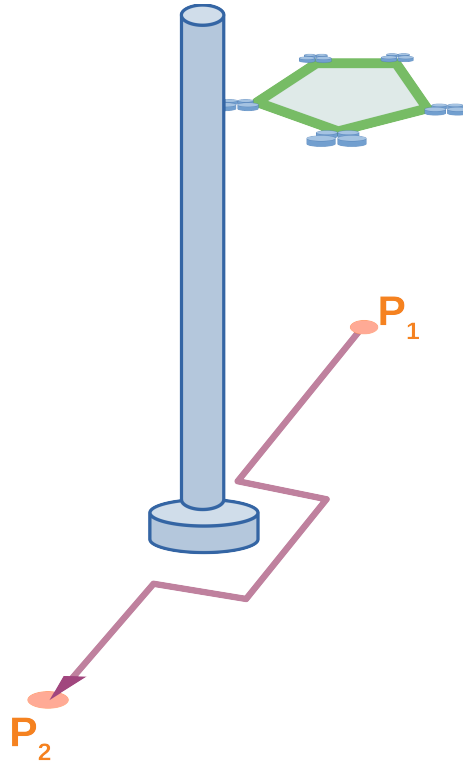[1] https://www.hindawi.com/journals/jat/
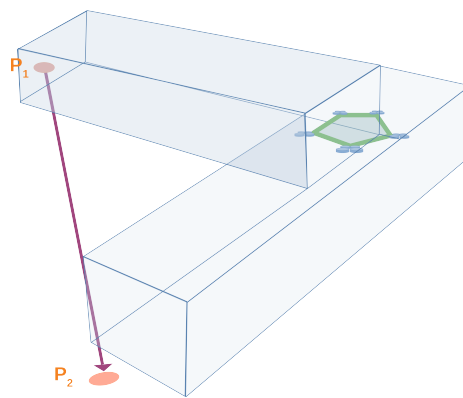
Figure 4: Collective vertical obstacle avoidance
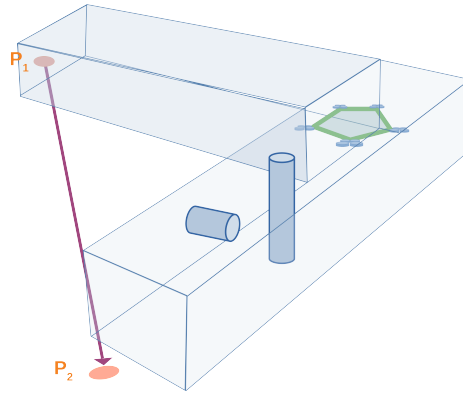

Figure 5: Collective turning drones

Figure 6: All the collision avoidance scenarios which help the system to avoid collision

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