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## I. INTRODUCTION

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$$\alpha + \beta = \chi \qquad (1)$$

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use (1), not Eq. (1) or equation (1), except at the beginning of a sentence: Equation (1) is . . .

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- The subscript for the permeability of vacuum ?0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter o.
- In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
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- There is no period after the et in the Latin abbreviation et al..
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TABLE I

AN EXAMPLE OF A TABLE

| | |
|---|---|
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| Three | Four |

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Fig. 1. Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity Magnetization, or Magnetization, M, not just M. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write Magnetization (A/m) or Magnetization A[m(1)], not just A/m. Do not label axes with a ratio of quantities and units. For example, write Temperature (K), not Temperature/K.

## V. CONCLUSIONS

A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

## VI. OUTLINE

1-Introduction
2-Potential Field Based Approach
Burada Samitha Pubudu daki denklemleri nasil yeniden yazdigimizi anlatalim kisaca
3- Bubble Packing
Samitha Pubududaki artificial forcelari shape partitioning icin nasil kullandigimizi anlatip 4 lu algoritmayi verelim
4-Evaluation
Settling Time- Total Displacements
Dynamic formation- Bubble Packing deki gecikmeler

5-Conclusion

## VII. ABSTRACT

Formation control in robotics is a growing topic where research works are mainly geared towards heterogeneous swarm colonies under either decentralized control or limited centralization. Swarm robotics where decentralization is applied, nevertheless assume that the agents are capable of getting global information about the whole swarm.Moreover in the literature, formation control is generally done for known fixed shapes that can be defined mathematically. However no dynamically changing shapes are envisaged and no shape transitions are clearly handled in those works. In this project, we attempt to bring a clear impact to the literature by focusing on tracking and realizing formation shapes under dynamically changing formation shape demands. We have proposed a novel method named Bubble Packing method for dynamic formation control and compared the performance of this method with artificial forces method which is generally used in literature in formation shape generation problems.

## VIII. INTRO

Formation control problem have different subproblems like formation shape generation, formation reconfiguration&selection and formation tracking [1]. In formation shape generation, agents are expected to get a formation shape which can be defined by external commands or with some mathematical constraint functions [2]. One general approach is to consider artificial potential functions. Samitha and Pubudu [3] have presented an artificial potential function method based on the consideration of the problem as controlling the position of a swarm into a shape, bounded by a simple closed contour. This approach results in deploying uniformly of swarm agents within the contour. Their work provides analysis about the stability and robustness of the proposed system based on Lyapunov like functions. In their work, desired formation shapes are defined with some analytical expressions and individual control laws for agents are composed with artificial potential functions by using these analytical expressions. In real world applications, it may not be possible to have the analytical expressions of the desired formation shape. In our project, we have focused on designing control laws which do not depend on the analytical expressions of the formation shapes.

In some applications, it may be needed to change the formation shape or splitting and joining of the agents together due to either a change in coordinated task requirements or change in environmental conditions such as narrow corridors. In such a scenario, the swarm has to propagate in a narrow corridor before reaching the desired goal state and it is not possible to follow this path by keeping the final desired formation shape. Hence, swarm has to adapt itself to environmental conditions while following a predetermined trajectory. This task requires formation reconfiguration and dynamic task assignment of swarm agents to be dispatched. Hou et al. [4] have defined a method based on global objective functions to provide formation control of a swarm. In their approach it is possible to implement scaling and rotating functions into control laws to adapt the swarm to environmental conditions while achieving a specific task. But their work only covers dynamics adaptation of the formation shape with scaling and rotation rather than dynamically change the shape randomly without any rule. On the other hand, their approach also requires the analytical expressions of the desired formation shapes.

One of the subproblems studied in formation control is formation tracking. The main objective of this problem is to maintain a desired formation with a group of robots, while tracking or following a reference trajectory. The solutions for the formation tracking approaches can be classified into three basic strategies as leader-following, virtual structure and behaviour based approaches [1]. The most general strategy to provide a solution for this problem is leader-following swarm structures [5]. Other strategies have a basis on optimization and graph theory approaches [1]. Kumar et al. proposed a vision based formation control framework for this problem. This framework has a leader following infrastructure [5]. In leader following strategy, some of the agents in the swarm are the leaders to manage the rest of the swarm to achieve a desired specific task and the rest of the agents act as followers. This approach reduces the formation control problem into tracking control problem of individuals to follow the leader from a desired distance and bearing angle, thus the stability and convergence analysis of the formation can be done with the usage of single tracking controllers of members. This approach simplifies the tracking problem of a network of agents to a single agent. Kumar et al. at [5], proposed a control framework in which follower agents move along a trajectory afterwards the leader agent with a desired separation distance $l_{ij}$ and desired relative bearing angle $\psi_{ij}$. In this approach it is hard to gather the agents in a certain shape. Another drawback is that, determining the separation and bearing angles for individual agents is getting harder as the number of agents in the swarm increases and this strategy is not fault tolerant to the absence of communication between agents.

In virtual structure approach, the formation is composed with a virtual rigid body. Formation control is applied to the whole virtual structure and then the individual agent control laws are determined with inverse dynamic solutions [1]. Lewis and Tan [6] proposed a virtual structure based method for formation control with a bidirectional flow control where robots move to keep the virtual structure when the swarm is following a trajectory and virtual structure adapt itself to the robots' current positions to compensate the relative errors at the end of a maneuver. In virtual structure strategy it is easy to achieve a coordinated behaviour for the group to maintain the formation during a trajectory tracking or a maneuvering, but it is not a suitable strategy to apply a formation control to achieve certain geometrical shape with the swarm agents.

Behaviour based strategies model every agents' behaviours to achieve specific tasks with swarm. These behaviours may be very simple like randomly walk and avoidance of obstacles in the environment or they may be defined in a very complicated manner in order to achieve complex formation shapes with the entire swarm while for example optimizing the overall energy consumption depending upon the implementation of the controller structures. One of the main usage of this strategy is artificial potential field based implementations . Cheng and Nagpal have introduced a robust and self repairing formation control method for swarms [7]. In this approach, individual control laws for the agents are defined with the artificial forces between agents themselves (to avoid collisions) and between the desired formation shape and agents. This solution provides robustness to the agent losses in the swarm during formation control and the rest of the swarm has the ability to refiil their absence in real time without changing the dynamics and the parameters of the formation controller. Because individual control laws are not dependent on the other member of the swarm. Each agent can calculate its own control input at an instant time with current formation shape and current members of the swarm and the whole swarm converge another equilibrium with current members [7]. One of the main disadvantage of the artificial potential based approaches is that , the control forces applied to individual agents are determined instantaneously in accordance with that agent's and the other agents' positions and they cannot guarantee the optimization of the total distance travelled by the agents. Another drawback related with this type of solution is that, there is a possibility to have local minimas in the solution where an agent reaches an undesired point in configuration space under the equilibrium of different types of artificial force components. In that case the total control input acting on the agent will be zero because of cancelling force vectors which has opposite directions to each other generated by formation shape and obstacles etc. In this strategy, the solution may converge slowly to the steady state due to absence of generalized goal states for individual agents in the final formation shape. Because, there are no specific goal states for the individual agents to reach at the final configuration and they are expected to get a global equilibrium with the help of different artificial force components.

Another approach is to define mathematical constraints and objective functions to achieve a specific formation shape by controlling the shape of the swarm colony while following a trajectory. Kumar and Belta [8] presented an abstraction method of configuration space to a manifold defined as $A = GxS$ where $G$ is a lie group representing the position and the orientation of the swarm and S represents the shape of the manifold. They provide individual control laws which can be separately handled to manipulate the lie group $G$ to achieve formation tracking and orientation control and to manipulate the shape $S$ to achieve different geometrical shapes.Their method defines the desired formation shape with shape manifold equations and control the orientation and the scale of this shape with lie group. Similarly Cheah and Slotine [4] proposed a method based on objective functions. Common drawback for these researches, they can only implement a limited number of simple geometrical shapes because the desired formation shapes must be analytically identified in order to compose the related objective functions or shape manifolds. Even if it is possible to define a simple geometrical shape and to control the rotation and the scaling of this shape dynamically, there may be need for more complex and dynamically changing formation shapes rather than scaling and rotation maneuvers in real time applications.

Specific tasks including different missions, requires agents with different capabilities and this kind of tasks may not be achieved with swarms composed of homogeneous agents [9]. In our work, one of the objectives is to implement a formation control system with heterogeneous agents. Furthermore, proposed solutions for formation control problem generally includes a decision making process which is executed by an individual agent or a central server. This kind of approach creates a single point of failure system and if this decision maker unit fails during mission, swarm cannot achieve the desired task. In this thesis work, it is aimed to implement a solution in which every agent is responsible of contributing on decisions and reaching a global consensus.

In this paper, we propose a solution named Bubble Packing method, to achieve the objectives discussed in this section. We have compared the performance of this method with the Artificial forces based method which is commonly used in formation control problems. We have implemented algorithms which can adapt itself to the dynamically changing formations for both of these methods.

## IX. Artificial Forces Method

In Artificial Forces method we have implemented potential fields over each agent arised from the interactions between agents, formation shape and environment. The final positions of the agents at the formation shape are determined with local equilibrium of the swarm in which every agent is at balance under the total force acting from the environment. Basically we have implemented three different kinds of artificial forces named; intermember forces representing the forces created by the other agents in the swarm to achieve collision avoidance, the attractive forces representing the forces created by the desired formation shape to attract the agent into the shape and repulsive forces created by the formation shape to keep agents inside the desired formation shape, obstacle forces to provide collision avoidance with workspace obstacles. We have updated the contour integral equations for these potential fields [3] to be calculated on complex formations shapes and obstacles which do not have analytical expressions as following.

Let $f(z)$ is a complex function in a domain $D$ in the complex plane and let $C$ be simple closed contour contained in $D$ with initial point $a$ and terminal point $b$. It is possible to take the integral of $f(z)$ along the contour $C$ [10]

$$\oint_C f(z)dz = \int_a^b f(z(t))\frac{dz(t)}{dt}dt \tag{1}$$

where

$$\frac{dz(t)}{dt} = \frac{dx(t)}{dt} + i\frac{dy(t)}{dt},\ a \le t \le b \tag{2}$$

To simplify this equation, one can write $f(z) = u(x, y) + iv(x, y)$ and $dz = dx + idy$ into the statements,

$$\begin{aligned}\oint_C f(z)dz &= \oint_C udx - vdy + i\oint_C udy + vdx \\ &= A + iB\end{aligned} \tag{3}$$

where

$$\begin{aligned}A &= \int_a^b \left[u(x(t), y(t))\frac{dx(t)}{dt} - v(x(t), y(t))\frac{dy(t)}{dt}\right]dt \\ B &= \int_a^b \left[u(x(t), y(t))\frac{dy(t)}{dt} + v(x(t), y(t))\frac{dx(t)}{dt}\right]dt\end{aligned} \tag{4}$$

Discrete representation of the (4)

$$\begin{aligned}A &= \sum_{k=1}^{K} u(x_k, y_k)(x_{k+1} - x_k) - v(x_k, y_k)(y_{k+1} - y_k) \\ B &= \sum_{k=1}^{K} u(x_k, y_k)(y_{k+1} - y_k) - v(x_k, y_k)(x_{k+1} - x_k)\end{aligned} \tag{5}$$

$$\begin{aligned}&\|z_k - z_{k-1}\| = \|z_{k+1} - z_k\|, \\ &\forall k;\ \ k = 1, 2, ..., K\ \ when\ \ K \to \infty\end{aligned} \tag{6}$$

The assumption of $K \to \infty$ makes it possible to calculate the integral of Cauchy winding number with a small error with large number of $K$ which can be achieved by partitioning the desired formation shape into small pieces with equal $p2$ norms of $\Delta z$. We have used this approach to provide representations of the contour integrals in discrete domain.

## APPENDIX

Appendixes should appear before the acknowledgment.

## ACKNOWLEDGMENT

The preferred spelling of the word acknowledgment in America is without an e after the g. Avoid the stilted expression, One of us (R. B. G.) thanks . . . Instead, try R. B. G. thanks. Put sponsor acknowledgments in the unnumbered footnote on the first page.

References are important to the reader; therefore, each citation must be complete and correct. If at all possible, references should be commonly available publications.

## REFERENCES


[1] Kiattisin Kanjanawanishkul. Formation control of mobile robots: Survey. n.d.

[2] Magnus Egerstedt and Xiaoming Hu. Formation constrained multi-agent control. *IEEE Transactions On Robotics And Automation*, 17:947–951, 2001.

[3] Samitha Ekanayake and Pubudu Pathirana. Formations of robotic swarm: An artificial force based approach. *International Journal of Advanced Robotic Systems*, 7:173–190, 2010.

[4] S.P. Hou, C.C. Cheah, and J.J.E. Slotine. Dynamic region following formation control for a swarm of robots. In *ICRA*, 2009.

[5] Aveek Das, Rafael Fierro, Vijay Kumar, James Ostrowski, John Spletzer, and Camilla Taylor. A vision-based formation control framework. *IEEE Transactions on Robotics and Automation*, 18:813–825, 2002.

[6] Anthony Lewis and Kar-Han Tan. High precision formation control of mobile robots using virtual structures. *Autonomous Robots*, 4:387–403, 1997.

[7] Jimming Cheng, Winston Cheng, and Radhika Nagpal. Robust and self-repairing formation control for swarms of mobile agents. In *AAAI 20th National Conference on Artificial Intelligence*, 2005.

[8] Calin Belta and Vijay Kumar. Abstraction and control for groups of robots. *IEEE Transactions on Robotics and Automation*, 20:865–875, 2004.

[9] Dorigo et al. Swarmanoid: A novel concept for the study of heterogeneous robotic swarms. *IEEE Robotics & Automation Magazine*, 20:60–71, 2013.

[10] Wikipedia. Methods of contour integration — Wikipedia, the free encyclopedia, 2016. [Online; accessed 10-February-2016].


## REFERENCES


[1] G. O. Young, Synthetic structure of industrial plastics (Book style with paper title and editor), in Plastics, 2nd ed. vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 1564.

[2] W.-K. Chen, Linear Networks and Systems (Book style). Belmont, CA: Wadsworth, 1993, pp. 123135.

[3] H. Poor, An Introduction to Signal Detection and Estimation. New York: Springer-Verlag, 1985, ch. 4.

[4] B. Smith, An approach to graphs of linear forms (Unpublished work style), unpublished.

[5] E. H. Miller, A note on reflector arrays (Periodical styleAccepted for publication), IEEE Trans. Antennas Propagat., to be publised.

[6] J. Wang, Fundamentals of erbium-doped fiber amplifiers arrays (Periodical styleSubmitted for publication), IEEE J. Quantum Electron., submitted for publication.

[7] C. J. Kaufman, Rocky Mountain Research Lab., Boulder, CO, private communication, May 1995.

[8] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, Electron spectroscopy studies on magneto-optical media and plastic substrate interfaces(Translation Journals style), IEEE Transl. J. Magn.Jpn., vol. 2, Aug. 1987, pp. 740741 [Dig. 9th Annu. Conf. Magnetics Japan, 1982, p. 301].

[9] M. Young, The Techincal Writers Handbook. Mill Valley, CA: University Science, 1989.

[10] J. U. Duncombe, Infrared navigationPart I: An assessment of feasibility (Periodical style), IEEE Trans. Electron Devices, vol. ED-11, pp. 3439, Jan. 1959.

[11] S. Chen, B. Mulgrew, and P. M. Grant, A clustering technique for digital communications channel equalization using radial basis function networks, IEEE Trans. Neural Networks, vol. 4, pp. 570578, July 1993.

[12] R. W. Lucky, Automatic equalization for digital communication, Bell Syst. Tech. J., vol. 44, no. 4, pp. 547588, Apr. 1965.

[13] S. P. Bingulac, On the compatibility of adaptive controllers (Published Conference Proceedings style), in Proc. 4th Annu. Allerton Conf. Circuits and Systems Theory, New York, 1994, pp. 816.

[14] G. R. Faulhaber, Design of service systems with priority reservation, in Conf. Rec. 1995 IEEE Int. Conf. Communications, pp. 38.

[15] W. D. Doyle, Magnetization reversal in films with biaxial anisotropy, in 1987 Proc. INTERMAG Conf., pp. 2.2-12.2-6.

[16] G. W. Juette and L. E. Zeffanella, Radio noise currents n short sections on bundle conductors (Presented Conference Paper style), presented at the IEEE Summer power Meeting, Dallas, TX, June 2227, 1990, Paper 90 SM 690-0 PWRS.

[17] J. G. Kreifeldt, An analysis of surface-detected EMG as an amplitude-modulated noise, presented at the 1989 Int. Conf. Medicine and Biological Engineering, Chicago, IL.
[18] J. Williams, Narrow-band analyzer (Thesis or Dissertation style), Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.
[19] N. Kawasaki, Parametric study of thermal and chemical nonequilibrium nozzle flow, M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.
[20] J. P. Wilkinson, Nonlinear resonant circuit devices (Patent style), U.S. Patent 3 624 12, July 16, 1990.