

**COLLABORATIVE URBAN SENSING:
BIO-INSPIRED APPROACH**

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**COLLABORATIVE URBAN SENSING:
BIO-INSPIRED APPROACH**

by

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Certificate

This is to certify that the thesis titled "COLLABORATIVE URBAN SENSING: BIO-INSPIRED APPROACH " being submitted by Mr. SUMANT MUKHERJEE to the **Department of Electrical Engineering**, Indian Institute of Technology Delhi, for the award of the degree of **Doctor of Philosophy**, is a record of bona-fide Research work carried out by him under our guidance and supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree. The results contained in this thesis have not been submitted to any other university or institute for the award of any degree or diploma.

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To my family

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Sumant Mukherjee

Abstract

This thesis explores use of bio-inspired approach for collaborative urban sensing involving motion coordination and task allocation among sensor nodes. We propose a novel unified bio-inspired model for multi-agent spatial motion coordination. A unified model of bio-inspired mechanisms of attraction/repulsion, spreading, aggregation and evaporation is proposed that helps aggregate information received by agent from environment for motion control decision making.

Next we present cooperative mobile sensing architecture for distributed estimation of sensor data, motion control of sensor nodes and task allocation to the nodes. For cooperative sensing we propose a distributed sensor fusion algorithm that uses measurements from neighboring sensor nodes to iteratively reach agreement on estimate

of the scalar field using linear consensus protocol. For mobility coordination between mobile sensors for sensor measurements, we develop a distributed motion-control algorithm that adaptively senses the scalar field for improving quality of sensing. For coverage of the entire field by mobile sensors, we develop a distributed task allocation algorithm that assigns target locations to sensor nodes taking into account currently unexplored areas.

Finally we present mobile crowd sensing (MCS) framework for delay tolerant online opportunistic task allocation. We mathematically formulate optimization problem for maximizing MCS task utility while maintaining constraint of tasking environment. Utility optimization is achieved in two stages of user registration and task allocation. In first stage the server selects a subset of users that are predicted to achieve required coverage of cells by end coverage cycle.

In the next stage the server selects subset of sensing opportunities (i.e. specific user at specific sensing location) in each sampling cycle for maximization of total utility by end of coverage cycle while

maintaining given task constraints. To solve these combinatorial hard problems we use heuristic approach of ant colony optimization (ACO) to propose two novel algorithms for user registration and task allocation.

सार

इस थीसिस के लिए जैव प्रेरित दृष्टिकोण का उपयोग करना पड़ता है गति समन्वय और कार्य को शामिल करने वाले सहयोगी शहरी संवेदन सेंसर नोड्स में आवंटन हम एक उपन्यास एकीकृत बहु-एजेंट स्थानिक गति समन्वय के लिए मॉडल एक एकीकृत आकर्षण / प्रतिकर्षण के जैव प्रेरित तंत्र का मॉडल, प्रसार, एकत्रीकरण और वाष्पीकरण प्रस्तावित है जो कुल में मदद करता है गति नियंत्रण के लिए पर्यावरण से एजेंट द्वारा प्राप्त जानकारी निर्णय लेना।

इसके बाद हम सहकारी मोबाइल सेंसिंग आर्किटेक्चर को प्रस्तुत करते हैं संवेदक डेटा का वितरित अनुमान, सेंसर नोड का गति नियंत्रण और नोड्स के लिए कार्य आवंटन। सहकारी संवेदन के लिए हम एक को प्रस्तावित करते हैं वितरित संवेदक संलयन एल्गोरिथम जो कि माप का उपयोग करता है पड़ोसी संवेदक नोड्स अनुमान पर समझौते पर पहुंचने के लिए रैखिक आम सहमति प्रोटोकॉल का उपयोग करके स्केलर क्षेत्र का गतिशीलता के लिए सेंसर माप के लिए मोबाइल सेंसर के बीच समन्वय, हम वितरित गति नियंत्रण एल्गोरिथम विकसित करें जो अनुकूली इंद्रियों संवेदन की गुणवत्ता में सुधार के लिए स्केलर क्षेत्र इस कवरेज के लिए मोबाइल सेंसर द्वारा पूरे क्षेत्र, हम एक वितरित कार्य आवंटन विकसित करते हैं एल्गोरिथम जो सेंसर नोड्स में ले जाने के लिए लक्षित स्थानों को आवंटित करता है खाता वर्तमान में बेरोज क्षेत्रों

अंत में हम मोबाइल वीड सेंसिंग (एमसीएस) ढांचे को प्रस्तुत करते हैं सहिष्णु ऑनलाइन अवसरवादी कार्य आवंटन देरी हम गणितीय एमसीएस कार्य उपयोगिता को अधिकतम करने के लिए अनुकूलन समस्या तैयार करना जबकि कामकाजी वातावरण की बाधा को बनाए रखना उपयोगिता ऑप्टिमाइजेशन उपयोगकर्ता पंजीकरण और कार्य के दो चरणों में हासिल किया गया है आवंटन। पहले चरण में सर्वर उन उपयोगकर्ताओं का एक सबसेट चुनता है जो कि हैं अंत कवरेज चक्र द्वारा कोशिकाओं की आवश्यक कवरेज प्राप्त करने की भविष्यवाणी अगले चरण में सर्वर सेंसिंग के अवसरों के सबसेट का चयन करता है (यानी, विशिष्ट सैनिसिंग स्थान पर विशिष्ट उपयोगकर्ता) प्रत्येक नमूना चक्र में कवरेज चक्र के अंत तक कुल उपयोगिता को अधिकतम करना दिए गए कार्य बाधाओं को बनाए रखना इन संयोजनों को कठिन हल करने के लिए समस्याएं जो हम चींटी कॉलोनी ऑप्टिमाइजेशन (एसीओ) के

परिचयात्मक दृष्टिकोण का उपयोग करते हैं उपयोगकर्ता पंजीकरण और कार्य के लिए दो उपन्यास एल्गोरिदम का प्रस्ताव आवंटन।

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