

Pre-Thesis

In fulfillment of the requirements for the PhD candidacy examination

Optimal deployment of static sensors for industrial leak detection using a Multiobjective Evolutionary Algorithm (MOEA)

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**Abstract**

**Introduction**

Degraded air quality is a consequence of heightened emissions from a wide range of pollution sources, both anthropogenic, such as transportation or industry and natural, such as dust plumes, wildfires or vegetation. Dense urban centers and industrialized regions serve as “hotspots” in a continuum of concentrations, dictated by the rate by which all emitted substances undergo transport, diffusion, chemical transformation and  deposition to the ground (Atmospheric chemistry and physics). Fossil fuel combustion processes (taking place in...) are major emitters of gaseous pollutants to the troposphere, mainly sulfur dioxide (SO2), nitrogen monoxide (NO) and dioxide (NO2) (known as NOx),  carbon monoxide (CO) and dioxide (CO2), volatile organic compounds (VOCs) and others. Particulate pollutants, known as particulate matter (PM), are emitted as well in combustion processes and can be divided to primary particles (such as black carbon (BC)) and secondary particles (like sulfates and nitrates) which are formed in the atmosphere by oxidation of primary gaseous pollutants. Another secondary pollutant is the ozone (O3). Like other secondary pollutants, it is produced naturally in the troposphere by photochemical oxidation of primary pollutants by the hydroxyl radical (OH). Many other anthropogenic pollutants are emitted from various industrial processes, and these include X from Y, X1 from Y1.

The main incentive to reduce and control emission rates from anthropogenic sources is of course insuring population health. World health organization (WHO) estimates that 4.2 million premature deaths globally are linked to ambient air pollution, mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children. Pollutants with the strongest evidence for public health concern include particulate matter (PM), ozone (O3), nitrogen dioxide (NO2) and sulfur dioxide (SO2) (WHO,2019).

Epidemiologic studies try to evaluate (assess?) past population exposure to air pollution and correlate the level of exposure to observed health effects in the population. The major challenge in this type of work is in producing accurate pollution concentration maps of high spatial and temporal resolution that can enable finding such correlations at a personal level such as the exact place of residence of a subject. These studies rely on data of ambient pollution concentrations usually obtained by two methods; i) routine measurements reported by standard air quality monitoring (AQM) stations, ii) short-term measurement campaigns which usually utilize large number of sensors. Evaluations using the first method are considered very accurate, since AQM stations are equipped with expensive, pollutant-designated measuring devices, that are maintained and calibrated on a regular basis by regulatory authorities. However, these tend to suffer from a few apparent flaws; i) their span is usually sparse, and cannot represent well the spatial and temporal variability of a typical pollutant (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2233947/), ii) samples of air are taken a few meters above street level and hence cannot represent well the extent of exposure of a passerby, and iii) they are costly to maintain. Short-term measurement campaigns on the other hand can provide a higher spatial resolution of the desired region of research, but for a limited time only, and are rarely adequate for a comprehensive epidemiological study. In the past couple of years, citizen science projects had become more common, and large amounts of air quality data are being collected today by individuals, usually using low-cost sensors of various types. Using such data however requires an exhaustive preprocessing work as reliability of some of the measurements might be questionable.

(MAYBE MISSING SOME CONNECTION HERE) Spatial interpolation methods (IDW, Kriging) may help overcome sparse representation of concentration and can be used to produce pollution dense maps of certain locations and times. Land use regression (LUR) models link environmental variables (road type, traffic volume, topography, land cover) with measurements in monitoring locations and then use these variables as model predictors at unmonitored locations, and possibly as predictors in time. Nevertheless, dispersion models are the only method that can quantify the deterministic relationships between sources’ emissions and concentrations in space and allows the identification of the causes for the air quality problem itself.

*Atmospheric transport and dispersion (ATD) models are used to forecast the spread of the contaminants to provide emergency responders with crucial intelligence to aid efficient response and post emergency assessment. For an accurate forecast, several variables are needed as an input to the model including, but not limited to: meteorological data, the strength of the release and its location. In general, sparse meteorological data are available from local weather stations or even across the globe. The strength, location and time of the release are often unknown, and thus should be inferred from relevant sensor measurements*

*עד כאן, מה שאקבל אם אנסה לייצר מפות של זיהום אוויר בשיטה כזאת או אחרת. ייצור מפה מדויקת ברזולוציית זמן ומרחב גבוהה דורש ממני נתונים של הפליטות ברזולוציה הזאת*. לא תמיד הנתונים האלו לגבי המקורות זמינים, ולכן הרבה עבודות עוסקות בבעיה ההפוכה - ב-source term estimation. כלומר, לוקחות נתוני מדידה מחיישנים (נתונים אלו הם לרוב ספארס, ויש להם רעש) ומנסים להעריך פליטה ממקורות.

בישראל, מפעלים רבים מדווחים רק על הפליטות השנתיות שלהן באמצעות מפל"ס/מצאי. דיגומים על בסיס קבוע נעשים על ידי המשרד להגנת הסביבה, אך אלו מתרחשים פעם במספר חודשים בלבד. ניטור רציף קיים בחלק מהארובות/המפעלים בלבד. לכן, מידע ברזולוציה גבוהה (פליטות שעתיות) של מפעלים לרוב אינו בנמצא או משוערך על ידי פקטורי פליטה ממוצעת שמתחשבים בין היתר בזמני הפעילות הידועים של המפעל וקצב הייצור.

עבור הרגולטור, קיימת מוטיבציה להעריך את קצב הפליטה השעתית לשם אכיפה ופיקוח על מפעלים שאינם חורגים מהיתרי הפליטה שניתנו להם (עד כדי סטיית תקן מסוימת).

עבור האזרחים, המוטיבציה היא בריאותית. since health impacts can be triggered by both short-term exceedances of pollution thresholds or long-term continuous exposure to high pollution levels (Van Roosbroeck et al., 2006; Beelen et al., 2008; Lelieveld et al., 2013)

Emission rates from industry are being controlled by regulatory bodies, such as the ministry of environmental protection. A Pollutant Release and Transfer Register (PRTR) is an inventory of pollutants released to the environment by plants. In Israel, a PRTR is produced by the  ministry of environmental protection every year. It is based mainly on the plants’ statements, which are confirmed by quality assurance procedures. Some plants have monitoring equipment and others rely on occasional samplings which enable the calculation of a ratio between the emission rate of the pollutant and  the production rate during the sampling.

על איזה מזהם אוויר אני מדברת ?

The proposed work is

**Research objectives**

**Research contribution**

**Literature review**

**Research plan**

**Methods**

קצת על מודל דיספרסיה גאוסי

על איזה מזהם אוויר אני מדברת ?

**בעתיד:**

**להשתמש במודל דיספרסיה מתוחכם יותר**

**להשתמש במקרה בעולם האמיתי**

**אולי לוותר על המודל דיספרסיה ולעשות ML ?**

**Initial results**

**Work schedule**

**References**