**Statistical Effectiveness of Predictive Policing Algorithms**
(Technical Paper)

**Societal Impact of Predictive Policing Algorithms in Crime Prevention**

(STS Paper)

A Thesis Prospectus Submitted to the

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Artificial intelligence (AI) and machine learning (ML) algorithms have redefined the world, fundamentally reshaping how modern systems and technology behave and "transforming every walk of life" (Allen & West, 2018). However, with the overwhelming potential AI and ML provide, it is even more important that issues of data privacy, security and bias are taken into account to ensure society is positively impacted by its application (Chui, et al., 2018). This prospectus seeks to analyze the application of AI/ML algorithms towards predictive policing, known as predictive policing algorithms (PPAs), which aim to predict future locations and victims of crime using previously reported incident data for use by policing forces in crime prevention. PPAs are stated to greatly improve policing effectiveness, allowing for "policing that is smarter, more effective, and more proactive" and "allows police to make better use of limited resources" (Perry, et al., 2013, p. 1). However, this also comes with controversy over their implementation, with critics claiming that PPAs reinforce the current racial and economic bias present in policing. According to Amnesty International (2020), PPAs would reproduce or amplify any human biases that are inherent to the dataset used, which in the context of crime disproportionately affects certain races and socioeconomic status. Similarly, Selbst (2017) notes that software engineers may inadvertently design algorithms which discriminates towards certain groups of people.

The technical state of the art and tightly coupled STS research paper proposed in this prospectus seek to evaluate these potential impacts of using PPAs in crime prevention using the Social Construction of Technology (SCOT) framework. This technical state of the art report will analyze current implementations and results of algorithms used for predictive policing, such as PredPol, which has been employed in over 50 police departments within the US (Smith, 2018), and explore proposed frameworks which improve on current implementations to maximize

algorithmic fairness and effectiveness in crime prevention. The paired STS will expand on this by exploring current and potential PPA impacts on society, how PPAs are shaped by current public perception, and the direction we should take to better use PPAs in the future. This work will be accomplished during the Fall 2021 and Spring 2022 semesters amounting to a total of 28 weeks, as depicted in Figure 1.

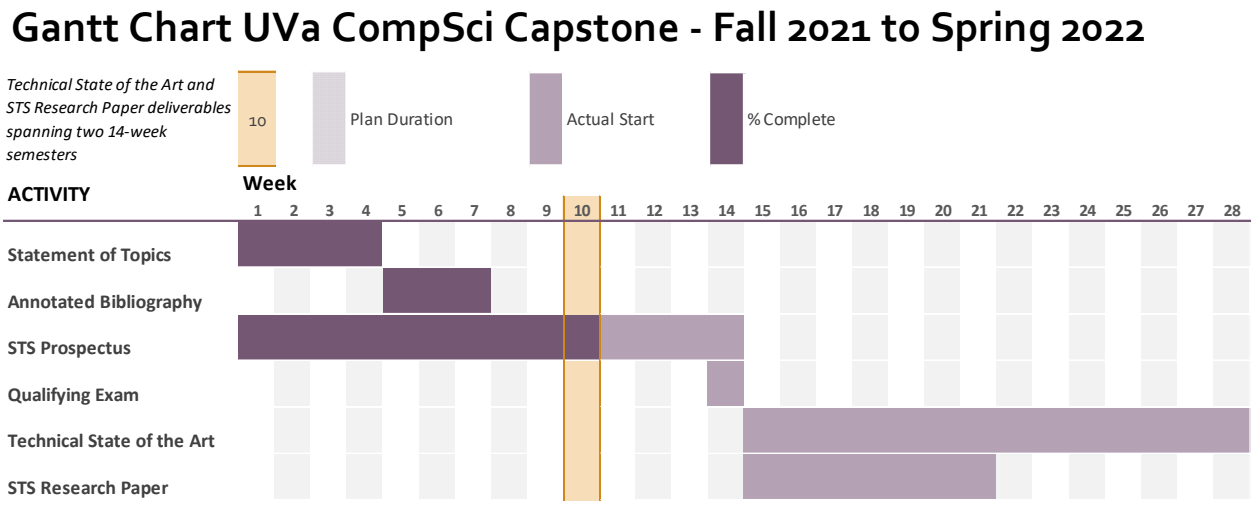



Figure 1: Gantt chart UVa Computer Science capstone. This figure shows the expected timeline for the major deliverables on the technical state of the art and STS project. (Smith, 2021).

## DESIGN AND IMPLEMENTATION OF PREDICTIVE POLICING ALGORITHMS

Although there are a vast amount of iterations and potential implementations of predictive policing algorithms, one of the most widely used and most criticized is PredPol, an organization that "predicts crime using cloud software technology that identifies the highest risk times and places in real-time" ("PredPol Overview", 2021). PredPol (2021) works by using historical event datasets to train its algorithm for whichever city it works in, then feeding in new data as the department receives it each day. PredPol only uses 3 data points within these datasets – crime type, crime location, and crime date/time – in order to create their predictions. As

PredPol puts it, “No personally identifiable information is ever used. No demographic, ethnic or socio-economic information is ever used. This eliminates the possibility for privacy or civil rights violations seen with other intelligence-led or predictive policing models” (PredPol, 2021).

In terms of software, PredPol interfaces with patrol operations by using a grid of 500 x 500 feet boxes and mapping the raw data of predicted crime frequency, which can be seen in Figure 2, into a google map web interface which will highlight the highest-risk boxes on the grid in red, which can be seen in Figure 3. These predictions are categorized based off shift (day, swing or night) with officers then being instructed to patrol these predicted ‘crime hot-spots’ for ~10% of their shift time (PredPol, 2021). PredPol then offers an array of data analytics using tracking software within police cars to determine anything the department might need – allowing them to track how much each hot-spot was patrolled, create patrol heat maps to determine areas that might be over- or under-patrolled, or even creating specific missions where PredPol will give you a predictive breakdown of what you might expect going into the area (PredPol, 2021). All of this is really aiming for

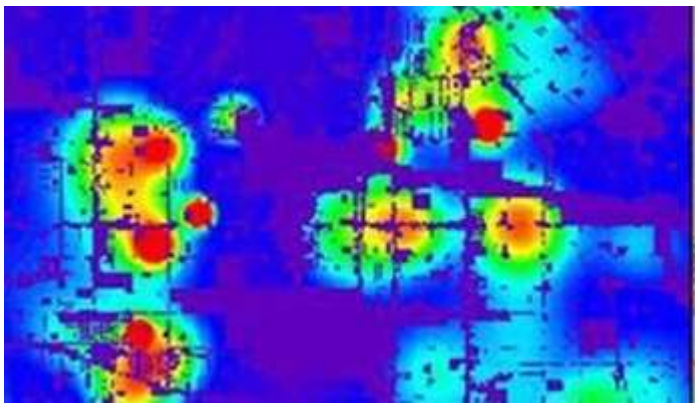


Figure 2: Predicted Crime Heatmap. This figure shows a probabilistic heatmap of the precise locations for predicted crime frequency, with areas in red being more susceptible to crime. (Meilani, 2018).

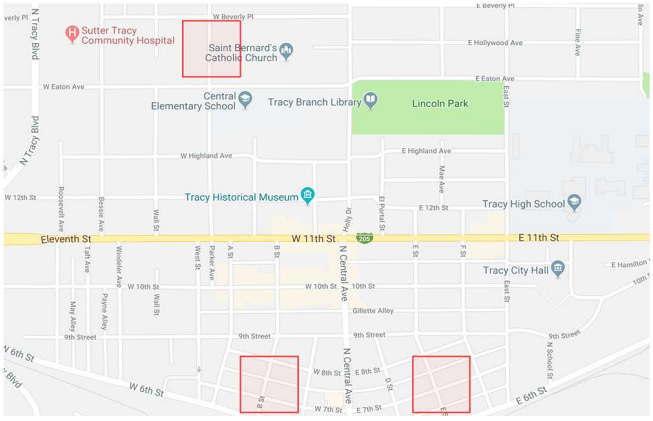



Figure 3: Crime Hot-Spot Mapping. A google maps web interface showing the location of the highest-risk boxes for predicted future crime locations (PredPol, 2021).

PredPol to be used as a real-time crime center for use by policing departments for the most efficient and effective crime prevention.

## ALGORITHMIC ANALYSIS AND EFFECTIVENESS OF PREDICTIVE POLICING

Although PredPol states that it does not use personal or socioeconomic information, there should still be a concern more generally about any bias present in both the data and algorithm used in implementations of PPAs. According to Lum & Johndrow (2016), although it is perceived that algorithms produce unbiased results due to the 'neutrality' of computers and the exclusion of any variables which may introduce bias (e.g. race, income, etc.), the employment of algorithms actually retain and even amplify bias because training data is generated by a process that is inherently biased. Based on Lum & Johndrow's research, they demonstrate that the most common approach of companies like PredPol is to create 'race-neutral models', the exclusion of using race as a variable, still results in a racially biased outcome. Instead, they propose a predictive model which removes bias by removing all protected information that might be present in the dataset used, which their research shows removes racial bias with minimal impact to the predictive accuracy of the algorithm (Lum & Johndrow, 2016).

Another area of concern with predictive algorithms lies within their actual effectiveness in crime prevention and if their application would be practically useful to police departments. In order to quantify the effectiveness of PPAs, one must compare how PPAs perform relative to a human crime analyst that does manual predictions. Research done by Mohler, et al. (2015), which performed two randomized controlled trials of real-time epidemic-type after sequence (ETAS) crime forecasting, found that ETAS models predicted 1.4-2.2 times more crime relative to a typical crime analyst with the same amount of data, and that predictions from ETAS models allowed patrols to reduce the volume of crime by an average of 7.4% relative to the norm.

Similarly, research done into PredPol determined that its application in various trials has resulted in a 27% drop in burglary incidents from 2010-2011 (Bachner, 2013), the prediction of 50% of gun homicide locations (Ferguson, 2017), and an overall crime prediction rate of 4.7% relative to the 2.1% of typical crime analysts (Ferguson, 2020).

The technical state of the art report, the objective will be to synthesize these stated aspects of predictive policing algorithms: current implementations and use cases of PPAs, current algorithmic design and new potential algorithms, and the effectiveness of applying current and potential algorithms towards crime prevention. This report will allow for a concrete overview on the current and potential capabilities of PPAs and will allow me to use an accurate representation of their implications when applied to my STS research project.

## SOCIETAL IMPACTS OF PREDICTIVE POLICING ALGORITHMS

Although we have shown how predictive policing algorithms (PPAs) have been successfully implemented and have a demonstrable impact on crime prevention, many are critical of PPAs due to the potential societal ramifications it brings, especially during a time of increasing criticism towards policing. According to Yen and Hung (2021), a majority of the criticisms against PPAs can fall into three main arguments, of which we will use two: PPAs serve to reinforce existing institutional abuses of power within policing, and the training data and algorithms used by PPAs produce a heavy amount of bias, mainly towards those targeted by policing in the past. The criticism pointing towards institutional abuses of power is highlighted by the changing landscape in the US political sphere, where recent events such as the police killing of George Floyd has heavily influenced police criticisms and calls for reform. This has led to governments such as the city of Santa Cruz, California to ban police use of PPAs, warning

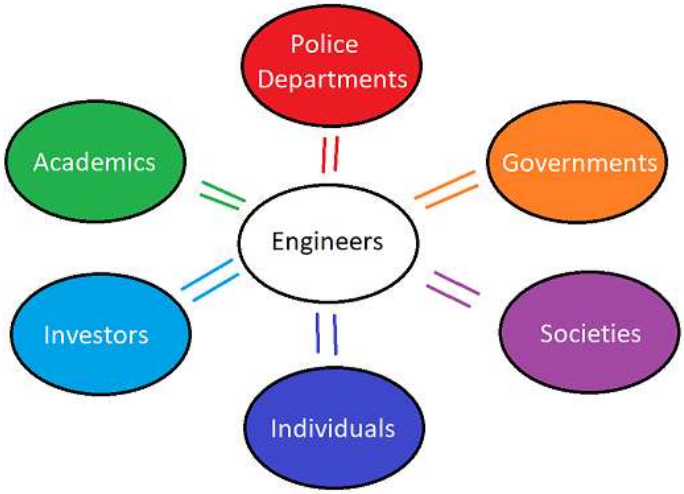
that they contribute to racial profiling and can serve as justifications for police abuse (Uberti, 2020). Similarly, academics have criticized the potential for bias in the training data and algorithms used by PPAs, which was already shown to be the case in Lum and Johndrow's research (2016), and how they directly contribute to racial and socioeconomic discrimination performed by police (Yen & Hung, 2021).

Additionally, academics are concerned with the lack of transparency, awareness and peer-reviewed empirical research when it comes to PPAs. As put forth in the paper by Shapiro (2017), current predictive policing implementations are very closeted when it comes to their approach, and this causes much concern considering the amount of variance that is possible when it comes to what types of crime the algorithms can predict or block out, and the amount of bias that is possible if the algorithm or data is not suitable. In a similar research paper, Meijer and Wessels (2019) conclude that it is impossible to come to reasonable conclusions in regard to current implementations of PPAs due to the fact that there is a severe lack of empirical research that's been done into the field of predictive policing, and much of its supporting evidence is entirely anecdotal.

Because of the amount of criticism directed toward them, PPAs have begun readjusting their focus as a response to the criticisms. For example, PredPol has recently renamed to Geolitica, and has begun shifting part of their product towards tracking of police movements and patrol management to optimize their movements with their forecasts, instead of directly interacting with the predicted crimes (Uberti, 2021). However, Geolitica's CEO, Brian Macdonald, points out that he still believes there is a place for PPAs in crime prevention despite criticism, stating "We were just identifying high-risk locations that officers could patrol" (Uberti, 2021, para. 10). This brings up an important point in the discussion, as although current

implementations of PPAs are flawed, academics such as Yen and Hung (2021) point out that these issues are not an inherent part of PPAs but rather an issue with the way they are currently implemented. As has been previously pointed out in the technical project, there are recently researched frameworks which exist like the one presented by Lum and Johndrow (2016) that can solve the issue of racial and socioeconomic bias by minimizing their existence within data sets and algorithms without majorly impacting PPA effectiveness. Similarly, PPAs could be made much more transparent and brought in-line with the public agenda, by having public hearings, increasing government oversight into PPAs, and funding much more research into PPA effectiveness and potential downsides. These potential improvements on the current implementations of PPAs will be further explored as a core aspect of my STS research project with the implications of the technical state of the art being considered.

Through this consideration on the current and potential societal implications of predictive policing algorithms, the social construction of PPAs will be investigated. This will be done using the Social Construction of Technology (SCOT) framework developed by Bjiker, Hughes and Pinch (1984). Within this model, which is visualized in Figure 4, each group provides its own resources and feedback of PPAs to the engineer, and in return the development of PPAs by the engineers will reflect the interests and concerns. By understanding these interactions between the engineers and groups of




engineer provide to each other, causing the engineer to make tradeoffs in development to satisfy each group. (Smith, 2021).

interest, the types of decisions and tradeoffs that the engineer makes in the development of PPAs can be realized and allow for the understanding of the social construction of PPAs. Through this SCOT model, the potential future implementation of PPAs can be approximated and considered.

This STS research project will be a scholarly article outlining the societal impacts of the current implementations of PPAs, how PPAs are continually being shaped based on the social construction of its development, and the direction PPAs should be taken to better impact society along with the potential ramifications of doing so.

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