# Predictive Policing: Big Data and Crime Prevention

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In the following paper, we will discuss the opportunities and risks of the application of big data in predictive policing. We will first give a short overview of the general background of predictive policing, the different sorts of predictions, the mathematical analysis methods and finally their usage in the work of the police. Then we will give a brief outlook on several cases, where predictive policing methods have been applied in practice. Finally, we will discuss the societal, ethical and legal aspects of the application of big data in predictive policing and summarize our results.

*Keywords:* predictive policing, big data, evidence-based policing, machine learning

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## Introduction

To stop the crime before it happens is the dream of every policeman and the holy grail of criminology. Now a new technology called predictive policing has made its attempt to create an elixir: using big data and machine learning to effectively predict the time and location of potential criminal activities. Although a novel idea, it has already been tested and implemented in several states in the US, including California, Washington and South Carolina. With many optimistic results coming out, predictive policing has the potential to revolutionize future police work and consequently our daily life. However, before accepting this technology into our norm, we still need to gauge its potential impact on both our physical and mental life. Having this in mind, we think it is necessary to discuss this topic in a rather broad context - consisting of the technological, ethical, society and historical aspects - instead of being limited to the technology itself.

## Definition of predictive policing

Predictive policing refers to the use of methods for predicting crime scenes, offenders, perpetrators, and victims\(^1\).

\(^1\)As suggested by Perry, McInnis, Price, Smith, and Hollywood, 2013
A brief history of the development of predictive policing

In an age of anxiety, the words sound so reassuring: predictive policing. The first half promises an awareness of events that have not yet occurred. The second half clarifies that the future in question will be one of safety and security. Together, they perfectly match the current obsession with big data and the mathematical prediction of human actions. They also address the current obsession with crime in the Western world especially in the United States, where this year’s presidential campaign has whipsawed between calls for law and order and cries that black lives matter. A system that effectively anticipated future crime could allow an elusive reconciliation, protecting the innocents while making sure that only the truly guilty are targeted.

It is no surprise, then, that many versions of predictive policing have been adopted (or soon will be) in Atlanta, New York, Philadelphia, Seattle and dozens of other US cities. These programs are finally putting the enticing promises to a real-world test. Based on statistical analysis of crime data and mathematical modelling of criminal activity, predictive policing is intended to forecast where and when crimes will happen. The seemingly unassailable goal is to use resources to fight crime and serve communities most effectively. Police departments and city administrations have welcomed this approach, believing it can substantially cut crime. William Bratton, who in September stepped down as commissioner of New York City’s police department the nation’s biggest calls it the future of policing. The notion of crime forecasting dates back to 1931, when sociologist Clifford R. Shaw of the University of Chicago and criminologist Henry D. McKay of Chicago’s Institute for Juvenile Research wrote a book exploring the persistence of juvenile crime in specific neighborhoods. Scientists have experimented with using statistical and geospatial analyses to determine crime risk levels ever since. In the 1990s, the National Institute of Justice (NIJ) and others embraced geographic information system tools for mapping crime data, and researchers began using everything from basic regression analysis to cutting-edge mathematical models to forecast when and where the next outbreak might occur. But until recently, the limits of computing power and storage prevented them from using large data sets. In 2008, researchers at the University of California, Los Angeles (UCLA), and UC Irvine teamed up with the Los Angeles Police Department (LAPD). By then, police departments were catching up in data collection, making crime forecasting “a real possibility rather than just a theoretical novelty, says UCLA anthropologist Jeffrey Brantingham. LAPD was using hot spot maps of past crimes to determine where to send patrols a strategy the department called “cops on the dot.” Brantingham’s team believed they could make the maps predictive rather than merely descriptive. To turn this insight into a predictive model embodying ‘good social science and good math’, as Brantingham puts it, he recruited several UCLA mathematicians to work on the problem in 2010 and 2011. One of them, Postdoctoral scholar George Mohler, now a mathematician at Indiana
University-Purdue University, Indianapolis, suggested that borrowing models from seismology might be useful. Earthquakes take place at a relatively fixed rate along existing fault lines, but quakes can also occur in clusters, when an initial quake is followed by aftershocks occurring near in time and space, Brantingham explains "Crime is actually very similar." Some crimes are caused by built-in features of the environment, like a bar that closes at 2 a.m. every night, unleashing rowdy drunkns on to neighborhood. Others, such as a series of gang murders or a rash of neighborhood burglaries, happen because criminals' success invites more crimes or incites retaliation. Criminologists call this "repeat victimization" the criminal equivalent of aftershocks. As he explains it, human behaviour often shows 'a well-defined underlying statistical distribution'. Knowing the distribution and drawing on past records, a data scientist can develop algorithms that give 'fairly accurate estimates of the probability of various behaviours, from clicking on an ad to committing, or being the victim of, a crime'. Mohler’s big finding was that ‘self-exciting point processes’, the statistical model that describes the aftershocks that follow earthquakes, also describes the temporal and geographic distributions of burglaries and other crimes. This result, published in the Journal of the American Statistical Association in 2011, is the basis of the ETAS algorithm (epidemic type aftershock sequence) at the heart of the PredPol software. In 2012, Brantingham and Mohler founded and remain involved with the PredPol company in Santa Cruz, California. In 2015, it was projected to raise revenue in excess of $5 million.

Brantingham and Mohler developed an algorithm now a proprietary software package called PredPol that predicts what will happen within a given police shift. The software, used by 60 police departments around the country, incorporates a narrow set of closely related crime events from both the immediate and longer-term past, with more recent crimes given heavier weight. The software strips personal details and looks at "only what, where, and when," Brantingham says. At the beginning of a shift, officers are shown maps with 150-by-150-meter boxes indicating where crime is likely to flare up. Fighting crime, the company says in promotional slides, is about "getting in the box." PredPol is not alone. Police departments can choose from among several competing products including HunchLab, whose development by the Philadelphia-based Azavea Corporation began in 2008. HunchLab is used in Philadelphia and in Miami, was recently installed by the St Louis County Police Department after the Ferguson shooting, and is under test by NYPD. This is emblematic of the rapid spread predictive policing. According to the criminologist Craig Uchida of Justice and Security Strategies Incorporated: ‘Every police department in cities of 100,000 people and up will be using some form of predictive policing in the next few years.’ In Pittsburgh, Carnegie Mellon data scientists Wil Gorr and Daniel Neill developed similar program for Chief McLay not long after he arrived in 2014. A fit, genial man who looks like Mr. Clean, McLay previously held what he calls a "retirement job" as leadership development consultant, working with the International Association of Chiefs of Police, before returning to active policing; he decided to get back into active policing just days after Michael Brown, an unarmed black man, was killed in Ferguson, Missouri, triggering nationwide protests. McLay was convinced that improving the use of data policing would lead to better outcomes. Like PredPol and HunchLab, Pittsburgh’s CrimeScan program has a geographic focus, but it draws on a broader variety of indicators. Gorr and Neill took their inspiration from criminology research showing that criminals tend to be generalists, and they tend to progress from minor to more serious crimes. As a result, the duo hypothesized, reports of minor crimes could help predict potential flare-ups of violent crime. In a gang confrontation, Neill says, “maybe it starts out with harsh words and offensive graffiti, and turns into fist fights, which turn into shootings, which turn into lots of shootings.” Along with observations from the recent past, CrimeScan incorporates scores of minor crime offenses and 911 calls about things like disorderly conduct, narcotics, and loitering to spit out predictions about city blocks likely to see upsurges in violent crime in the next few days or weeks. The Chicago police department (CPD), meanwhile, has taken predictive policing one step further and made it personal. The department is using network analysis to generate a highly controversial Strategic Subject List of people deemed at risk of becoming either victims or perpetrators of violent crimes. Officers and community members then pay visits to people on the list to inform them that they are considered high-risk. The Custom Notification program, as it’s called,
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was inspired in part by studies done by Andrew Papachristos, a sociologist at Yale University. Papachristos grew up in Chicago’s Rogers Park neighborhood in the 1980s and ’90s, at the height of the crack era. Being white insulated him from some of the violence, he says: “The color of my skin meant I never had to join a gang.” But one night, Papachristos watched as a gang burned his parents’ diner to the ground because they refused to pay extortion money. Decades later, when he started studying crime, Papachristos wanted to understand the networks behind it. For a 2014 paper, he and Christopher Wildeman of Cornell University studied a high-crime neighborhood on Chicago’s West Side. They found that 41% of all gun homicide victims in the community of 82,000 belonged to a network people who had been arrested together, and who comprised a mere 4% of the population suggesting, with other studies, that much can be learned about crime examining the company people keep, he says.

These seemingly show great success. The companies reports that the LAPD Foothills Division saw a 13 per cent reduction in general crime in the four months after PredPol was installed, compared with a 0.4 per cent increase in areas without it. In Atlanta, crime fell by 8 per cent and 9 per cent in two police zones using the software but remained flat or increased in four zones without it; and an ‘aggregate’ 19 per cent decrease in crime across the city was attributed mostly to PredPol. The company also cites double-digit percentage decreases in crime after the software entered service in smaller cities.

Such numbers have impressed elected leaders in city halls across the US. Eager to find answers to both long-standing and current issues in policing, they have quickly adopted the predictive approach. In 2013, Seattle’s mayor Mike McGinn announced that an earlier trial of PredPol would be expanded citywide. In 2014, Atlanta’s mayor Kasim Reed praised predictive policing in The Wall Street Journal, writing that Atlanta’s use of PredPol resulted in crime ‘falling below the 40-year lows we have already seen’. He added: ‘In the future, police will perfect the use of predictive analytics to thwart crimes before they occur’ a welcome prediction today when belief in the ‘unbiased’ nature of computer algorithms would seem to smooth out sharp political differences about crime levels in the US. In 2013, Chicago police used data to identify and put on a ‘hot list’ some 400 people considered likely to be involved in fatal shootings as shooters or victims. The number has since been raised to 1,400, many of whom have received ‘custom notifications’ home visits by police to warn them they are known to the department. However, a just-published RAND Corporation study of the original 2013 project shows that it did not reduce homicides. The report states that individuals on the hot list ‘are not more or less likely to become a victim of a homicide or shooting than the comparison group’, but they have a higher probability of being arrested for a shooting. Nevertheless, a similar effort is now under way in Kansas City, Missouri. A separate RAND assessment of predictive program developed and used by the police department in Shreveport, Louisiana concluded: ‘The program did not generate a statistically significant reduction in property crime.’

The effectiveness of predictive policing was recently tested by the Los Angeles Police Department (LAPD), which found its accuracy to be twice that of its current practices. In Santa Cruz, California, the implementation of predictive policing over a 6-month period resulted in a 19 percent drop in the number of burglaries. In Kent, 8.5 percent of all street crime occurred in locations predicted by PredPol, beating the 5 percent from police analysts.

Technical background and systems currently used

Currently, the most popular software used in predictive policing is PredPol, first used by police departments in Los Angeles and Santa Cruz and later adopted in some other metropolitan areas. According to its website, the software has some “scientifically proven” results, mainly around 10%-30% drop of crime rate after
the deployment of the software by different police departments.

The algorithm of PredPol. The algorithm used by this software revolves around the self-exciting point process model. According to a paper titled Self-Exciting Point Process Modeling of Crime (Mohler) cited on the website, the self-exciting point process was used in seismology for predicting earthquakes, but it can also be applied in criminology for predicting crimes. The link between the two seemingly unrelated areas is that both crimes and earthquakes have a higher chance happening in areas where such events happened before. Thus it is possible for researchers to use the same modeling method to generate an accurate hotspot map of crimes, which is extremely useful for police departments, since in large cities such as Los Angeles and Santa Cruz, crimes can be significantly reduced by effective patrolling.

Machine learning. Furthermore, machine learning plays an important role in predicting crimes. As the patterns of crimes are ever-changing, it is necessary for any crime prediction software to adjust its model dynamically according to the newest data. For example, PredPol uses a self-learning algorithm called Epidemic Type Aftershock Sequence (ETAS) Model to process several years of data to lay down a “background” level of crime patterns and to understand how crimes propagate throughout the city. Every six months, PredPol re-learns the patterns using all historical and recent crime data and thus keeps itself always up-to-date. Researchers from MIT collaborated with Cambridge Police Department (CPD) in developing a new machine learning-based method "Series Finder", which builds its database on the data collected by CPD in the past decades and further grows it upon everyday crime data (Rudin).

Societal implications

Predictive policing and police bias. One problem occurring through predictive policing is that it reinforces the biases which are already present within the police. This is established though the way predictive policing works, since the algorithm is fed with data, which is not complete. This means that not all crime is recorded by the police, which means that the algorithm does not learn about the patterns of crime itself, but about the occurring crime which is recorded by the police. This then leads to one substantial problem, namely that the algorithm will not predict crime in an area where the police did not record it before, but it will predict even more crime in areas with a high number of crime reports which occurred before. If then the police officers are told to show a higher presence in the areas where most of the crimes were reported before, they are more likely to record even more crime in these areas, leading into a cycle which will always target certain areas. This will especially lead to problems if a certain community has been considered a higher risk area before (e.g. a poor community of color) since there were more crimes recorded, and now it will be patrolled even more. This then leads to the problem that many police officers will have a higher suspicion towards everyone in these areas, which increases tension between the police and the citizens. This can for example be seen in the New York City Police Department where the Police Department is sued by citizens for an overuse of the so called “stop and frisk” policy, which was executed by police officers in certain communities. More than half a million citizens, of which most were of color, were stopped and frisked nearly every day for more than a year. By raising the general suspicion for certain areas, this will likely result in even higher numbers, since it can lead to an increased level of reasonable suspicion. Another question raised is whether people in areas which are a result of predictive policing,

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4Lum, n.d.
3Ferguson, n.d.
4Times, n.d.
5Coquillard, 1995.
6Capers, n.d.

can be automatically reasonable suspicious, when the main argument is that they are in this area. This is a current topic of discussion, since some people see this running counter to the Fourth Amendment, and the New York City Police Department completed stop-and-frisk forms for 867,617 individuals. Among them, 453,042 were black, and another 30% were Hispanic, numbers grossly disproportionate to their representation in the general public. Only one in every 21.5 blacks stopped was found to be engaged in activity warranting arrest. Put another way, of the 453,042 stop-and-frisk forms police officers completed for black suspects, approximately 402,943 were for stopping and frisking blacks not engaged in unlawful activity.

Due to this fact some people see predictive policing as tool which increases (existing) discrimination. To assure that this is not the case, predictive policing will need to be checked for its accountability in data and analysis, since it could otherwise have a serious impact on peoples living quality in some areas, if being a forecast area and e.g. not matching the expected type of citizen, e.g. a colored person living in a wealthier white neighborhood, with a number of recent burglaries could be targeted by officers, since he does not meet the expected picture of a citizen belonging to this neighborhood. This could cause a huge problem in the future, since a high number of police departments around the world are also using community policing. If the relationship between the police and the citizens is dominated by tension and problems, tips and reports by the community are probably getting less, which then would take back the advantage of the community policing. Furthermore, if the attitude towards the police departments is getting worse and worse, this will also have an impact on the police officers themselves, as they will receive more negative feedback for their work, mistrust and resistance.

**Garland’s theory of the “alien other”**. Another potential problem related to this issue is predicted by Garland’s theory of the “alien other”, which states that there is always fear towards something which is different. This is can become a big problem in the future, since our world is becoming more and more globalized, and through we will have a more and more mixed society. If this effect continues, it will cause more and more problems, especially because prejudices are applied to a growing number of people, therefore causing continuously more tension, not only in the relation between law enforcement and citizens, but also within our society.

**Courtroom Effect.** Another point is the Courtroom Effect, which describes the possible impact of the predictive policing within courtrooms. The main point here is that the software is mainly seen as objective, and so might be accepted as a reason to justify a case of reasonable suspicion. This is especially a problem if there are no mechanisms implemented to ensure the accountability if this data, since people in forecasted areas could be stopped and searched without any legit reason (apart from being in that area).

**Ethics of predictive policing**

We want to first emphasize that the big potential difference in the opportunities and risks related to different kinds of predictive policing methods applied. Especially the used data set, the reaction to the kind of predictions being made, the reactions to the predictions and the analysis of outcomes can differ, however these parameters are very important for estimating the risks and threats related to predictive policing. In the following, we will especially focus on applications using many different data sources (big data) and making comprehensive predictions (see subsection ??). The application of predictive policing consists of various different parts, namely the following:

**How does it work in practice; The SARA (Scanning, Analysis, Response, and Assessment) Model**

1. Collecting and gathering data on which the later predictions and analysis will be based upon.
   - If further data sources than just police records are used, it requires an additional step to fusion the data (which can be very tricky, especially as the validity of the information is heterogeneous).

2. Analyzing the data and producing predictions (interpolations) for the future.

3. Responding to the predictions

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8. Times, n.d.
4. Analysis of the results and evaluation of the effectiveness of the response.

In the following discussion, we will focus mainly on the first and second point, but we will also mention the last one.

Reliability and effectiveness of police work

In general the use of predictive policing is expected to improve the overall effectiveness of the police work. As discussed earlier, the results of past applications of predictive methods seems promising, although there are only few controlled evaluations of the cases where predictive policing has been applied and the results of a large scale application are yet to be seen. As later on we will also criticize some currently used predictive policing systems, challenging this evaluation.

Still, we should also be careful not to expect miracles. The computer prediction of the probabilities of people being criminal or of the risks of crimes to happen at a given place and time are just that predictions of probabilities. The computer is not a crystal ball, but just a tool to estimate the named probabilities. It can not predict the future (as suggested by the phrase “predictive policing” or by some media reports\footnote{Goode, n.d.; Holt and Alexander, n.d.} its reliability strongly depends on the quality of the data and it is up to the police how to respond to the predictions. This is especially important when considering the previously mentioned courtroom effect (see subsection Courtroom Effect).

Evidence based policing. However, predictive policing can (independent of the actual usage of the predictions) offer the opportunity of a more evidence based approach of the analysis of the reliability and effectiveness of past responses (see the fourth point in Ethics of predictive policing). This approach is also known as evidence based policing\footnote{“Evidence-based-policing,” n.d.; Perry et al., 2013; Sherman, 1998.}, the usage of statistical analysis of police interventions. Moreover, when using evidence based policing the extension of the required analysis to predictive policing is only a small step.

Finally, the same statistical analysis that can be applied to patterns in crime records can also be used to analyze the police work itself. The idea is to use so called Early Intervention Systems\footnote{Robinson and Koepe, 2016.} to analyze and to forecast policemen’s behavior, identifying officers whose performance exhibits problems and then to provide some response to this problem (usually some sort of counseling or training). Even though the results of some applications of these systems seems promising\footnote{Robinson, 2016a.} they are currently used to a smaller extend than predictive policing predicting the behavior of the usual citizen.

Transparency of the predictive methods. However, from the comparison of predictive policing with evidence based medicine or the general idea of evidence based policy from which the term has originally been derived\footnote{“Evidence-based-policing,” n.d.}, we can already see some challenges that have to be solved in order to put predictive policing on an evidence based foundation. Firstly, at the present time most used products for predictive policing are proprietary software packages, whose functionality is intransparent\footnote{Robinson and Koepe, 2016.}, making an open scientific evaluation of its reliability and drawbacks very hard. In evidence based medicine any medical treatment would ideally have to be proven to be effective, in order to be applied. When comparing to todays predictive policing systems, it is clear that this standard is not satisfied. In this regard, we want to emphasize the need to verify and test a system for predictive policing before its application and to only use methods, which are known to be working (and as mentioned above this is not the case for at least most of the more advanced software systems currently in use). It has even pointed out that for most systems currently in use it is doubtful, whether they are actually improving the police work\footnote{Perry et al., 2013, “the increase in accuracy in moving from fairly simple algorithms to the most sophisticated and computationally intensive algorithms tended to be marginal.”} and whether they offer any advantage compared with very simple analysis methods\footnote{Perry et al., 2013} (or see section History of predictive policing).

Privacy and civil liberties concerns

Privacy concerns. One of the biggest problem in the usage of Big Data in predictive policing, especially the use of data sets different from simple crime records
are privacy concerns. The inclusion of further information sources in the analysis implies that police officers will have access to the underlying database (or at least to the conclusions drawn from it). As the concerned information are in many cases (of current systems) essentially social networking data, it means that the police has access to some part of the presumably “private” communication of the people, which raises both questions of privacy\(^{17}\) and of how to control the power that comes with the access to the data (for instance the possibility to sell the data or to use it to blackmail the subjects).

Privacy is a human right, since people need a private sphere an area in which they are save to experiment, try out new things and share past experiences, without constant fear of the potential consequences, should these things being publicly known. And this refers not primarily to unlawful, but to socially awkward behavior. In this sense, privacy is a basic human need just like sleeping is.\(^{18}\)

Furthermore, the data being used in the analysis is typically not only limited to the conversations of the people themselves, but also includes the one of the social surrounding of the subjects up to two Degrees of Association\(^{19}\) (as a comparison the NSA uses 3)\(^{20}\). Therefore, people are flagged not merely based on their on behavior but but of the behavior of their social surrounding. This obviously has potentially undesired societal consequences\(^{21}\).

**Flagging people.** Another issue related to the usage of Big Data in predictive policing is the flagging of people (or at least places, where they live) as being likely to commit crimes. It has been argued that one key principle of privacy\(^{22}\) is the idea that people can hide certain information from the police and even though this might lead to some criminals not getting caught.

Furthermore, the targeting\(^{23}\). This treatment of people purely based on statistical data can already be seen as a big thread\(^{24}\) to the presumption of innocence a fundamental principle in the constitutions of many states and also a human right according to the Universal Declaration of Human Rights.

**Discrimination.** Even, though the reliability of the general police work is expected to improve over all, the application of predictive and in many cases purely statistical analysis methods raises questions of discrimination (may it correspond to reality or not). Predictive policing relies on statistical labeling of people or areas to be worthy of further law enforcement attention and this very act is already inherently dangerous. Furthermore, since the analysis is strongly based on statistical information and trends, in other words data purely about correlations and not (believed) causalities and therefore has been criticized to be discriminating.

At this point we should also consider the so called sampling bias already mentioned above (see subsection The sample bias): As the police work is currently influenced by discrimination we should expect that the current victims of the discrimination are more likely to be observed by actually committing crimes. Therefore, the current crime records should also indicate this and the discriminated people will be watched even more intensively leading to an even bigger bias in the resulting crime statistics and so on. This way predictive policing can reinforce the discrimination already present.

The same effect might also be affecting the self-measurements of these tools leading to an unreasonable strong focus of the predictions as described for instance in Robinson, 2016b.

**Legal concerns**

Firstly, as mentioned above the very concept of predictive policing can already be seen as a tread to the presumption of innocence. Also the collection of data for the predictions can be problematical. As was one of the key results in the session summary of the first Predictive Policing Symposium in Los Angeles in 2009 “Predic-

\(^{17}\) Schneier, n.d.
\(^{18}\) Schneier, n.d.
\(^{19}\) Robinson, n.d.
\(^{20}\) Which still means, that the relations to the socially next 10000 people are evaluated, instead of the relation to the socially next 1000000 people
\(^{21}\) As it punishes people for their association with flagged peers.
\(^{22}\) Stanley, n.d.
\(^{23}\) And being targeted can definitely be undesirable. For instance in Los Angeles the targets on the list of presumably most dangerous 400 (later it even became 1400) inhabitants where visited by the police and told that they are on the list (Gorner, n.d.).
\(^{24}\) Funnell, n.d.
tive policing must be constitutional.” in order to put the necessary privacy threads on a solid legal ground.

Usage of predictive methods in military

It might also be interesting to consider the usage predictive methods not only in policing, but for instance also in military operation. For instance the US military has used predictive methods to look for patterns in attacks on military staff in Iraq. When developing methods for predictive policing, we should always also be aware, that the very same tools might also be used for military applications later on.

Conclusion

In the current world with all its complexity, discrimination and police violence, it is very tempting to use big data and mathematical tools to produce unbiased models. Therefore it is no surprise that many technology companies are already producing software tools that are claimed to reduce crime rates significantly. In this paper we have mentioned some promising results of the application of these systems, as well as some shortcomings which put the optimism into question. As it seems there are various pitfalls in the application of predictive policing and it has yet to withstand the test of time. In a word, while predictive policing is potentially very beneficial for society, we should still be very careful with its applications.

References


26Perry et al., 2013.

Robinson, D. (2016b). In 3 years, Chicago police have tripled their use of a secret, computerized “heat list.” Retrieved from https://medium.com/equal-future/in-3-years-chicago-police-have-tripled-their-use-of-a-secret-computerized-heat-list-da7a0594ee78


