<u>How to Profile, If We May</u>

by

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There is a social and technical debate on the merits of profiling airline passengers in order to stop ones who carry harmful matter. The social debate considers the ethical aspects of profiling and the technical debate is concerned with its effectiveness. Using modern game-theory, we discuss below the technical question: which passengers to search (thoroughly) in what priority.

The US Federal Aviation Administration has employed since 1999 a screening system called CAPS (Computer-Assisted Passenger Screening System), which identifies high-risk individuals who should be thoroughly searched before embarkation.

There have been calls saying that since CAPS profiling method reveals to terrorists who the high-risk passengers are, it is self defeating. A master-mind terrorist will simply recruit a low risk passenger, and be sure that (s)he gets through without a search. Motivated by this argument, it was suggested that simple random search will be more effective than profiling.

On the other hand, it should be clear that simple random search gives the terrorist a different added advantage. Prior to the challenge of having his selected carrier pass inspection, he faces the challenge of recruiting a willing carrier. If all passengers are searched with the same probability, the terrorist's first challenge becomes easier. By restricting his recruiting effort to passengers who are of a "willing-type," he improves his probability of recruiting without increasing the probability of them being searched.

The above reasoning leads to logical circularity. If we profile selectively, terrorists will recruit low risk passengers, so we are better off performing equal-probability random search. But if we perform equal-probability random search, terrorists will recruit the willing types, so we are better off profiling selectively to identify the willing types and search them. This type of circular reasoning is familiar to game theorists, who have optimal methods of solving such situations (known as zero-sum games).

As it turns out, the best search method should allow for both, profiling and randomizing (PAR). It should select passengers to search randomly, but apply different search probabilities to individuals with different profiles.

To explain PAR and its potential, we present an example of a simple and naïve game that involves one plane and a terrorist who will approach exactly one of the passengers to be a carrier. While highly oversimplified in comparison to the real process of recruiting carriers and inspecting passengers, this example is simple enough to explain the logic of PAR and its effectiveness in a few paragraphs. In this example, PAR vulnerability is five times better (lower) than profiling and nine times better than randomizing.

Before turning to the example, it is important to note that the same method, with more elaborate computations, may be applied to actual airport environments involving more than one flight, terrorists who may try to recruit more than one passenger, etc. No matter what the environment is, a method that combines profiling with randomization will always outperform methods that are restricted to only profiling or only randomizing. In addition, this is true in other situations that involve profiling, such as searching drivers for illegal drugs and customs searches in airports.

We also note that PAR would lead to a determination of the level of competency of airport inspectors (in the example below they are 100% competent; they always detect a carrier if they search him). Are we better off searching more passengers with inspectors that are not as reliable?

Turning to our simple example we have a flight with 100 passengers, 8 have a high willingness profile (HW), 1 has a medium willingness profile (MW) and 91 have a low willingness profile (LW). More precisely, when approached by the terrorist, the probability that a HW passenger agrees to be a carrier is 2%, whereas for a MW passenger and for a LW passenger the corresponding probabilities are 1% and 0.1%. Based on CAPS rate of 8% search, we assume that exactly 8 of the 100 passengers will be searched, and that a carrier will be found if, and only if, (s)he is searched. The question for the terrorist is which one of the 100 passengers to approach, and for the security officer is which 8 passengers to search.

We proceed to compute vulnerability index for the three methods. (1) Pure randomizing: select randomly 8 of the 100 passengers to be searched. (2) Pure profiling: search only the 8 passengers in the HW group. (3) Profiling and randomizing (PAR): Search each of the HW passengers with probability 0.9 and the MW passenger with probability 0.8 (this may easily be arranged, for example, with probability 0.1 search only the 8 HW passengers and with probability 0.9 draw at random 8 of the 9 passengers in the HW and MW groups combined).

The vulnerability index of a search method is computed to be the highest success probability that a terrorist can strategically obtain under the given method.

Under pure randomization, the terrorist's best action is to try to recruit one of the HW passengers. His probability of success is 0.02, and after multiplying it by the probability of passing the random inspection, which is 92/100, his overall success probability is $0.02 \times 92/100 = 0.0184$. Thus, **the vulnerability index of pure randomization is 1.84%.**

Under pure profiling, the terrorist's best action is to try to recruit the MW passenger. His overall success probability is 0.01, since, if recruited, there is no longer a question of his passing the inspection. Thus, **the vulnerability index of pure profiling is 1%.**

Under PAR it is less obvious what the strategic terrorist should do. If he tries to recruit a LW passenger the success probability is 0.001. If he tries to recruit the MW passenger his success depends on both succeeding in the recruiting and passing the inspection. Thus the success probability is the product $0.01 \times (1- 0.8) = 0.002$. Similarly, if he tries to recruit a HW passenger his success probability is $0.02 \times (1- 0.9) = 0.002$. So the best he can do is to approach either the MW passenger or one of the HW passengers and in either case his success probability is 0.002. Thus, **the vulnerability index of PAR is 0.2%**, substantially lower than the other two.

It can also be shown, that the search probabilities chosen above (0.9 for HW and 0.8 for MW) are the best (for a plane with this passenger composition): no other method could lower the vulnerability index to be below 0.2%.

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