Modeling the behavior of smuggling networks in Turkey and northern Africa via refugee influx analysis for better Search & Rescue readiness[☆]

Harris V. Georgiou (MSc, PhD)[1,1]

[a] *Department of Informatics & Telecommunications (DIT), National Kapodistrian University of Athens (NKUA/UoA), Greece*

Abstract

During the last two years, hundreds of thousands of refugees have traveled across the Mediterranean Sea, in perilous conditions and unsafe boats, resulting in thousands of dead and missing, despite the best rescue efforts from both sides. Data analysis and statistics may have an answer for the challenging task of predicting the flows of incoming boats and assisting in the prompt allocation of Search & Rescue (SAR) resources at the frontlines.

Keywords: refugee crisis, influx analysis, emergency response, search & rescue

Since January 2015, Europe has witnessed an unprecedented influx of refugees from regions of war and conflict in the Middle East, primarily Syria, Afghanistan and Iraq. For almost two years now, Greece and Italy have become the main entrance points for hundreds of thousands of people from the Middle-East, trying to get to central and northern European countries. According to the UNHCR, the IOM and the MSF, during 2015 more than a million people reached Europe from Turkey and northern Africa, seeking safety and asylum.

A perilous journey

There are only few passages across the sea borders between Greece and Turkey where the distance is 5-7.5 n.m., hence these are the points of interest for both the smuggling networks and the coast guard patrols. In 2015 alone,

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URL: `http://xgeorgio.info` (Harris V. Georgiou (MSc, PhD))

[1] H.G. is a post-doc researcher with NKUA and an R&D associate with University of Piraeus, Greece; general secretary of the Hellenic Informatics Union (HIU); volunteer diver/rescuer & first-responder with the Hellenic Rescue Team (HRT); coordinator of the Greek ICT4D group in various projects for the refugee crisis in Greece.

at least 856,723 people came to Greece via Turkey, 80% of which landed at the island of Lesvos in the northern Aegean Sea.

Nevertheless, the lack of proper infrastructure, first-response coordination, early warning and on-the-spot logistical support resulted in thousands of casualties. The sheer volume of the influx resulted in a total of 3,771 registered dead or missing persons in the Mediterranean Sea during 2015, more than 832 in the Aegean Sea. There were specific 24-hour time frames at the end of October and the beginning of November 2015 when small beaches in the northern shores of Lesvos, like the small port of Skala Sykamneas with a population of only a few hundreds, received over 120 boats landing there, each carrying 40-50 persons.

During 2015, the Hellenic Coast Guard and the Turkish Coast Guard together have rescued more than 177,000 people from the sea. It is estimated that roughly one in five people (1:4.84) coming across these passages ended up rescued from the water. The dead and missing (estimated) for the same period were at least 832, about two persons every nine boats that sank, or 1:214 passengers.

After the recent EU-Turkey deal in March 2016, the influx to the EU is shifting again from the Eastern (Greece) to the Central (Italy) Mediterranean Sea route, resulting in a sharp rise of dead and missing people in boat sinking incidents.

The boat trip from Libya to Italy is much longer and perilous than the crossings from Turkey to Greece, 8-12 hours for about 150 n.m. rather than 25-40 minutes for 5-7.5 n.m. in comparison. As a result, massive boat sinking and capsizing events every week are drastically increasing the death/missing total and the true death ratio in the Central Mediterranean Sea route to Europe. According to more recent numbers from IOM and MSF for the first quarter of 2016 show that the death ratio is 1:69 for Italy but 1:410 for Greece, i.e., almost six times deadlier in comparison.

It should also be noted that the deaths from sinking of migrant/refugee ships inbound to Italy are usually underestimated due to the difficulties in locating all the bodies in the open sea, as well as the under-reporting of passengers on board. Hence, the corresponding death ratio there may actually be as high as 1:30. Major events with sinking boats on April 2016 and 2014 reveal that the actual survival rates may be lower than 28%.

Despite the dreadful probabilities, migrants and refugees still prefer to make their attempt via sea to Greece or Italy rather than via land (mostly Turkish-Bulgarian borders) by a rate of more than 42:1, because sea borders are inherently harder to patrol, fence or deny rescue.

An event-response, not a disaster management task

One of the main reasons of the numerous shipwrecks, especially the ones with late response and many casualties in the Aegean Sea and the central Mediterranean Sea, is the total lack of any early warning/alerting system, which could provide some preparation time for the prompt and effective deployment of resources at the “hot” zones.

It is clear that, despite any efforts to find solutions in the political level for the refugee crisis at hand, the problems on the ground require well-informed decisions, high mobility and rapid response, in order to save lives. The primary concern for the SAR resources, the medical teams, the volunteers and the NGOs assisting in the humanitarian relief, as well as the proper logistics and warehouse management in the first-reception islands, are all focused on the influx of refugees via unsafe boats.

The general problem is inherently one of humanitarian crisis management; however, the major difficulty is not the lack of civil infrastructure (e.g. electricity, open roads, communications, etc) as in a large earthquake or a flood, but rather in the ability to allocate adequate resources rapidly in various spots. Therefore, one of the most important and challenging tasks for a successful operation in this context is to enlarge the time frame for short-term planning deployment, i.e., improve the capabilities of early warning & prompt alerting.

In operational terms, an early warning/alerting system for (expected) high refugee influx would provide invaluable time for the preparation and deployment of teams and equipment from staging posts to specific areas of interest, promptly and effectively, in order to save lives. This is a concept that is already included in emergency planning and emergency operations in other contexts, for example in forecasting water levels to issue early warnings for possible floods, assessing weather conditions to issue alert warnings for possible wildfires in forests, etc.

A new proposal: Refugee influx analysis & short-term forecasting

Based on publicly available data from UNHCR, volunteer rescuers/first-responders and Informatics scientists[2] have recently developed signal-processing methods for analyzing the incoming flows of refugee boats to the Greek islands.

Specifically, it includes a completely data-driven systemic analysis of the refugee influx data series, aiming at: (a) the statistical and signal-level characterization of the smuggling networks; and (b) the formulation and assessment of such models for predictive purposes, i.e., to produce short-term forecasting of the refugee influx, as part of an early warning/alerting protocol on a daily basis.

This study is an attempt to quantify and analyze in a systemic way the task of developing such early warning/alert systems in the context of refugee influx, using Greece and the Aegean Sea islands as the main paradigm. The goal is to identify the underlying statistical properties and the inherent "system" that produces this influx, without any prior knowledge of how the smuggling networks operate near the Turkish coasts.

[2] ICT4dasc – Greek ICT4D group, http://www.ict4dascgr.eu

What was done

The study[3] was based on official data provided by UNHCR sources for the daily arrivals of refugees in the Greek islands of the eastern Aegean Sea. Specifically, UNHCR provides detailed daily logs of people registered in the "hotspot" camps in the islands, as well as from verified sources (other NGOs, Hellenic Coast Guard, Frontex).

There are six main regions of interest in the Aegean Sea: the islands of Lesvos, Chios, Samos, Leros, Kos and the rest of the southern Dodecanese islands. The time frame used in this case for the data series is from 1-Oct-2015 to 16-Jan-2016, a total span of 108 consecutive days (almost 15 weeks). The analysis employed a wide range of statistical, signal-based and decomposition techniques, as well as fractal analysis.

There are several, very interesting results produced by the data analysis. First, the refugee influx is a highly random process, but not as much as to make it non-predictable, at least with regard to short-term (next-day) forecasting. In other words, the smuggling networks appear to have specific behavior and properties that can be identified and exploited by looking at the refugees flows alone.

During this specific time frame, there was a consistent average flow of 4,000-4,150 people per day, fluctuating plus or minus 2.200, with a slight bias towards the lower bound. The distribution follows the 2/3 rule adequately, which means that two out of three days' arrivals rested well within that range. The max peak of just over 10,000 on one single day was reached on October 2015.

One of the most important conclusions drawn from the analysis of the refugee influx is the exact patterns. Frequency analysis on the data series reveal that there is a very distinct periodic trend of 6.2-6.5 days long, which means that the main "pattern" of arrivals gets repeated roughly on a weekly basis. A more thorough examination of the almost-weekly periodic trend reveals that there is a significant preference to the Sunday/Monday 48-hour time frame for the highest weekly flows, while there is a "pause" with much lower flows for the 3-4 days that follow. This evidence almost certainly proves that the smuggling networks near the Turkish coasts operate in a (almost) two-day "burst" / five-day "pause" pattern, a very distinct characteristic of store-and-forward processes and buffers in data communications. In other words, instead of packets of data, here there are people ("data") that get forwarded in temporary staging areas ("buffers") near the coastline, before they are partitioned in boats ("packets") of 40-50 persons each and sent across the next staging area ("receiver") on the Greek side.

In terms of forecasting accuracy, the analysis shows that a three-week time window seems adequate for constructing such analytical models with sufficiently

[3]Georgiou H, Kiomourtzis I, Alexakos F, 'Refugee influx analysis for smart early-warning systems for the rescue/relief operations in the first-reception islands', SafeEvros 2016: New technologies for Civil Protection services, 22-25 June 2016 @ Alexandroupolis, Greece. http://dx.doi.org/10.5281/zenodo.59728 / http://dx.doi.org/10.5281/zenodo.59727

low error rates, as to make them operationally useful for SAR short-term planning. These results show that such models can be used successfully for short-term forecasting of the influx intensity, producing an invaluable operational asset for planners, decision-makers and first-responders.

Current situation and future insights

The EU-Turkey deal of March 2016 for handling of refugee and asylum applications had very significant and almost immediate effects to the refugee influx in the Greek islands of first reception. First, from mid-January 2016 and on, the daily influx of refugees was "compressed" as to make it through the borders before they close down completely, thus the statistical characteristics of the data changed significantly. Second, the registration of daily arrivals was not coordinated by UNHCR anymore, thus there were no reliable publicly available data on a daily basis for the weeks and months that followed.

With regard to the data analysis and the models developed, it has been established that the intensity of the daily arrivals at the Greek islands is strongly associated to specific external factors, such as weather conditions, changes in refugee handling policies by the EU, the intensity of fights in the war zones in Syria, etc. Some of these factors can be quantified and included in such models, others cannot.

The most promising external factor that may be used as "input" in these models is weather conditions. More specifically, it was pointed out empirically from early on that some weather elements are of utmost importance, such as wind intensity and wave height, while others were of lesser importance, such as rainfall, temperature, humidity or cloud coverage. Hence, winds (intensity/direction) and waves (height/period) are the two external factors that are now being investigated thoroughly, in correlation to the refugee influx data series.

The issue of localization is also a factor that may be considered in more detail. In this study, only the total influx was used as a single data series; however, if more data are available or in cases where the local influx rates are sufficiently high (e.g. in Lesvos), localized modeling may be conducted. Combined with localized weather information, such systems would be even more useful and preemptive life-saving tools in the field of SAR operations.

Preliminary results reveal very interesting insights on the inherent properties of the problem at hand. For example, there is a very strong negative (inverse) correlation between weather conditions and the intensity of refugee flows in the northern part of Lesvos island: strong winds and high waves translate to fewer boats coming across from Turkey; on the other hand, the south-eastern sea passage is much more protected due to local geography and, hence, the weather conditions around the island do not seem to affect the intensity of the refugee flows there. In general, the inclusion of weather conditions, especially winds and sea condition, in the forecasting models seem to almost double their accuracy. This is a work that is currently in progress and it is adapted appropriately to the

central Mediterranean Sea passage (Libya-Italy) for developing similar models for that region too.

In terms of an actual early warning/alerting module for integration into rescue/relief operations, especially in "hot" zones like in eastern Greece and southern Italy, these systems must be implemented with specific "alert levels" (usually four or five) as output accordingly, similar to the way such systems of Civil Protection agencies work in other contexts, e.g. for tsunamis, wildfires, floods, etc. Ideally, this module could be fed with live data from registration agencies and other open data sources, publicly available Internet sources and satellite feeds, in order to produce reliable real-time short-term early warning of possible 24/48-hour influx periods of high intensity. This is already investigated as an add-in feature in "Prometheus"[4], a virtual Emergency Operations Center (EOC) developed and deployed already in Chios since January 2016.

Conclusions

The analysis described here is a summary of the first-ever attempt to analyze the refugee flows from Turkey and northern Africa in a systematic and quantifiable way, in terms of producing reliable models for short-term localized forecasting. The challenge is to have such systems as decision-support tools for SAR preparation and readiness in the frontline.

These results show that such models can be used successfully for short-term forecasting of the influx intensity, producing an invaluable operational asset for planners, decision-makers and first-responders. It is expected that future extensions of these models, including weather factors will further increase their accuracy and their value as actual early warning tools in such life-saving operations.

It is clear that, as long as the conditions remain the same and the war zones in Syria, Iraq, Afghanistan and elsewhere force people out and away from their homes, refugees will continue to converge towards Europe via the Mediterranean Sea. Therefore, the need for such early warning/alerting systems will continue to be an imperative need in Greece, in Italy or elsewhere.

[4] 'Prometheus' – Emergency Operations Center (EOC) platform, http://prometheus.online