All the Protestors fit to Count:
Using Unmanned Aerial Vehicles to Estimate Protest Event Size

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Protest events are a hallmark social movement tactic. Large crowds in public spaces sends a clear message to those in authority. Estimating crowd size is important for clarifying how much support a particular movement has been able to garner. This matters for policymakers and public opinion alike. Efforts to accurately estimate crowd size are plagued with issues: the cost of renting aircraft (if done by air), the challenge of visibility and securing building access (if done by rooftops), and issues related to perspective and scale (if done on the ground). Technological innovation involving Unmanned Aerial Vehicles (or "drones") open a new opportunity to better estimate crowd size. In this article we adapt traditional aerial techniques to this new innovation and apply the method to small (1,000) and large (30,000+) events. Ethical guidelines related to drone safety and privacy are advanced, and we conclude with a discussion of whether our usage matches meets such standards.

Protest, methods, crowd estimation, privacy, surveillance,
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Protest Size Matters

Size matters for social movements (DeNardo 1985; Lohmann 1994; Oberschall 1994; McCarthy, McPhail, and Smith 1996). Whether it be the number of names on abolitionist-era petitions or the number of people present at a "million-man" march, the ability to mobilize people (especially as citizens and consumers) and engage in coherent claims-making is a hallmark of collective action. Visible and sizable mobilization matters for both the movement's target as well as the general public that so often mediates movement's effects (Agnone 2007; Burstein 2003). Visibility matters because the ability to clog a major thoroughfare or fill a notable landmark demonstrates strength in numbers.[i] This observation, like so many others, is strikingly similar to something the social theorist Charles Tilly (1999) has already said: public collective action efforts demonstrate WUNC—worthiness, unity, numbers and commitment.

Much of the conversation about protest size has focused on newspaper data. A number of problems have dogged this usage, however. It turns out that the *New York Times* and *Washington Post* covered fewer than half of all disorders that occurred between 1968 and 1969, for example (Myers and Caniglia 2004). In that period coverage was determined by event intensity, distance from the paper, event density, the city's population size, the type of actors involved and the day of the week. Newspaper coverage matters (or mattered in the 20th century) for media cycles, public opinion, and the concomitant sense of urgency policymakers feel regarding the issues that have brought people onto the streets. All news is not created equal. The punch line here is that violent riots in big cities get covered.

Recent work by Michael Biggs (nd) suggests that it is not the number of events that matter, as most studies emphasize, but instead their size. His analysis undermines an entire vein of movement scholarship that has drawn on newspaper data to explain protests. Biggs argues that it is protest size that explains newspaper coverage that gets indexed in the first place. Relevant here is Biggs' observation that protestors do their best to maximize their size at single events, not to spread themselves over many smaller events. Why else do they gather in capital cities and in front of Parliaments? His observation reinforces the findings of Myers and colleagues (Myers and Caniglia 2004; Ortiz, Myers, Walls and Diaz 2005). However unintentionally, this critique provides a backhanded compliment to newspaper data: journalists and editors do a remarkable job of noting large and significant events. Large movements also have the effect of creating opportunities for attracting new supporters, whether on the street or as conscience constituents who support from home. They also have the effect of creating hospitable environments for counter mobilization by other civil society actors (Meyers and Staggenborg 1996). Large numbers of people on the street also represent symbolic challenges to authorities and practical challenges for administrators and bureaucrats. The temptation, then, may be to engage in repressive or co-opting responses in the event movements' target entrenched interests. This is true whether the target is a university, hospital, church or government (Walker, Martin, McCarthy 2009). Size matters; for targets, for the general public, for newspaper editors, and for social movements themselves.

It stands to reason, then, that getting the size of protest right is of some significance. Political opportunities, it is widely noted, are only as real as they are perceived. If a movement perceives an opportunity where there is none, it is possible they may respond with enthusiasm and a redoubling of their efforts (Rasler 1996). In this way a closed opportunity opens. Perception might not be everything (after all, if a movement lacks the resources necessary to complement their enthusiasm, all may come to naught), but it is certainly a very real something. The same can be said of the threat experienced by institutional targets facing a challenge from a newly formed bloc of voters in a Parliamentary plaza or group of undergraduates mobilized on the campus quad. The salient point here is that *perceived* protest size matters. This is why so much effort has gone into contesting exactly how large an event is.

A "Million Man March" only has alliteration going for it if it turns out the number is inflated by one million. Protests are inherently political and politicized events. Thus, the *actual* number of protestors matters to at least one of the four concerned parties (i.e., movement, target, media, general public). The Million Man March itself is often cited as a prime example of the inadequacies of crowd size reporting (McPhail, McCarthy 1996; Watson, Yip 2011). Organizers of the event placed attendance numbers between 1.5 and 2 million. The United States Park Service estimated the crowd to be around 400,000 people. The discrepancies between the two numbers resulted in the legal action taken against the National Park Service by the March organizers. Nobody doubted that a tremendous number of people took a stand with Louis Farrakhan against the economic and social conditions of African Americans. But once again, it is not the number itself that matters, but its relationship to perception. Was the march a success or a failure? Whose interests were served by the varying answers to that question? In some ways the answer to this question is mediated by the gap between perception and reality of the event's size, factors themselves directly connected to the movement's perceived worthiness.

Estimating Protest Size Methods

So how best such crowds might be measured? A broad survey of crowd estimation techniques suggests there is significant methodological fragmentation across media, authorities, academics and social movement actors. Lay approaches range from naïve guestimates to politicized declarations of "actual size." Official approaches are often plagued by political factors (Kielbowicz and Scherrer 1986). Gitlin (1980) cites instances in which the *New York Times* simply passed along police estimates of Vietnam War protest sizes. Mann (1974) found newspaper estimates of crowd size often matched along the publisher's political leanings (as measured by their editorial board). Edelman (1986) found higher police estimates for established political candidates and lower for more radical groups from the left and the right, when compared to his use of the industry-standard Jacobs Crowd Formula (JCF) which we used in this study. Several of these examples are emphasized in new work by Michael Biggs (nd), which explicates these complications in great detail.

In what follows we will leave aside these politicized and haphazard approaches and focus our attention instead on the development of estimation methods within the scholarly literature on protests. Here it seems there is little debate, since the crowd size estimation method is fairly well established, despite a relative lack of attention to the issue. Estimation techniques among movement scholars appear to have remained virtually unchanged since the 1960s. Those readers eager for a significant reimagining of the status quo will be disappointed. What we propose here is rather a transposition of the existing methodological approach to a new platform.

Not insignificant improvements are demonstrated, but they are important improvements, not radical revisions.

The industry standard method of estimating the size of static crowds has been relatively stable for the past five decades (in this study we leave to the side moving crowds, clearly a matter for a subsequent study). Herbert Jacobs, a journalism professor at UC-Berkeley, pioneered the approach from an elevated angle, as he observed the Free Speech Movement's birth outside his office window. He noticed the concrete pattern in Sproul Plaza provided the perfect grid format for consistent estimation size. The refined version of this approach appeared in the *Columbia Journalism Review* in 1967. The central assumption is that loose crowds were comprised of one person per 10 square feet (0.93 square meter) of space, while the same person occupies only 4.5 (0.42 square meter) square feet in a dense crowd and a mere 2.5 square feet (0.23 square meter) in the front of an event, assuming of course that there is a "front of the event." The task, then, was to accurately estimate the (1) square footage of the site, (2) the percentage of the site occupied by participants, and (3) the density of the crowd. Considered together, these factors underline the principal of the Jacobs' Crowd Formula (JCF) and would allow any individual an accurate estimation to any crowd size. In table 1 we apply general assumptions to several recent sites of protest.

Table 1: Public gathering places and carrying capacities at different density levels

		Number of people at 1 person per -		
	Area in Square meters (in sq. feet)	$0.23\ m^2$ ($2.5\ ft^2$)	$0.42\ m^2$ ($4.5\ ft^2$)	$0.93\ m^2$ ($10\ ft^2$)
Int’l football field	10,800 (116,250)	46,956	25,714	11,612
US football field	5364 (57,733)	23,321	12,771	5768
National Mall (US) (total area between the Ulysses S. Grant Memorial and the Lincoln Memorial)	1,200,000 (12,916,692)	5,217,391	2,857,142	1,290,322
Trafalgar Square (UK)	21,000 (226,042)	91,304	50,000	22,580
Tiananmen Square (China)	380,000 (4,090,286)	1,652,173	904,761	408,602
Red Square (Russia)	70,000 (753,474)	304,347	166,666	75,268
Tahrir square, Cairo, Egypt (Square + surrounding areas)	85,000 (914,932)	369,565	202,380	91,397
Maidan, Kiev, Ukraine	68,000 (731,946)	295,652	161904	73,118
Kossuth Lajos ter (Parliament Square, Budapest, Hungary)	40,000 (430,556)	173,913	95,238	43,010

NOTE: Area calculations were done on Google Earth Pro (Trial version). They can also be done by similar tool such as Atterbury or Daftlogic. While calculating we also included surrounding areas that also have crowd carrying potential. Those surrounding areas might include green areas, parks, wide streets, crossroads, etc. Our estimates occasionally differ from those found elsewhere (e.g., http://en.wikipedia.org/wiki/List_of_city_squares_by_size)

Jacob’s principal has been redefined and adapted a number of times (Seidler, Meyer, Gillivray 1976; Swank 1999; McPhail, Clark and McCarthy 2004). In the 1970s, the United States Park Police developed a formula of their own (McPhail and McCarthy 2004). Others incorporated aerial photography from helicopters and official site measurements from city square footage plans. Taken together these factors allow for a more accurate assessment than what Jacob’s formula in general would account for. These improvements to accuracy were made at the margins, the importance of the original three factors—site dimension, percentage occupancy, density—remained intact.

The JCF reached its current industry standard formulation through the work of Clark McPhail, who has consulted extensively on the issue. McPhail and McCarthy (2004) add one component (comparative data) to suggest four rules for the most credible estimation of crowd size:

1. Carrying capacity of site;
2. Density of the crowd;
3. Observations from multiple vantage points, some of which must be elevated;
4. Combined direct onsite estimation and indirect passenger volume estimation.

This approach is notable for its integration of both the direct estimation recommended by Jacobs as well as complementing that data with assessments of other measurements, such as the number of busses used to bring people into an event from far away (a practice as common in New Delhi as in Washington D.C.).

We have established that real and perceived crowd size is important, that accurate assessments of crowd size are important, and that there is in fact a relatively stable approach for measuring crowd size. The shortcoming in this method, we argue, is that it is difficult to secure multiple vantage points from which to watch or photograph a crowd. Movement actors do not usually have access to the roofs of the buildings surrounding the protest space. Significant crowds may form in places other than those anticipated by authorities, journalists, or even the movement itself. Multiple crowds may converge in different locations simultaneously. In these, and countless other conditions, observation from multiple elevated vantage points is simply impossible. Of course these obstacles can be overcome by having an airplane or fixed-wing aircraft secured for the day of the event and deployable to consecutive locations on a moment's notice. This solution, however, has two significant weaknesses: (1) it is expensive, usually well beyond what any movement actor is able to afford; and (2) it assumes open airspace, something that cannot be counted on in many of the political contexts where authorities feel threatened (e.g., the FAA closed the airspace over Ferguson, Missouri at the height of the protests over state repression there).

In what follows we argue that drones provide the benefits of a helicopter or fixed wing aircraft (multiple vantage points at altitude) without the associated challenges (cost and airspace access). In providing an extension of the JCF to a new technological platform (the quadcopter) we provide civil society actors with a means for securing affordable, easily deployable, high quality, aerial footage of protest events and a method for easily analyzing this visual data.

A Drone-Based Crowd Estimation Method

The method, in brief

We use a consumer-grade unmanned aerial vehicle (UAV,[ii] or drone) to implement the Jacobs Crowd Formula (JCF, hereafter). While we suggest several modifications (listed below) they are simple extensions of the JCF. Thus, the main advantage of the proposed method is its ease of use. While more sophisticated crowd counting techniques are available, using complex mathematical modeling, these require special computing and financial resources and specific technical knowledge (and are usually optimized for CCTV footage). They are therefore difficult to replicate in places where these resources are difficult to obtain. While the technical details of the method are spelled out in greater detail elsewhere (Choi-Fitzpatrick and Juskauskas 2015), a brief overview of the approach bears mentioning.

Step 1: Drone platform – All tests in this study were conducted with a commercially available DJI Phantom Vision 2. We chose this device for five reasons: it was the industry standard at the time of testing; no additional equipment is required for flight; its GPS capabilities allow it to be flown quickly and safely by pilots with a range of experience; it has a "return home" function that ensures a safe landing if the operator is detained or the link is broken; and it is a "prosumer" product, meaning it combines some professional features with a consumer price point.[iii]

Step 2: Digital image – We made one important modification to our device: We modified the UAV to ensure the camera was angled perpendicular to the ground, effectively eliminating issues related to estimating at an angle—an issue that plagues Jacobs estimates from rooftops. We used commercially available software to eliminate the "fish-eye effect."

Step 3: Area measurements – The process for securing an area measurement are described in greater detail in Choi-Fitzpatrick and Juskauskas 2015). In the first we laid a 10- meter marker onto the ground and used that as our reference point. Once the exact length of the reference point or line had been determined, we used publically available software (GIMP) to translate it into pixels as this is the unit of analysis for digital imagery. Table 2 shows a few dimension-sizes at three standard altitudes.

Table 2. Area Measurements and Crowd Estimation

	A		B		C
Altitude in meters (feet)	Photo dimensions in pixels after fish-eye correction	Fish-eye correction in GIMP software (main, edge)	Reference on ground in M (ft)	10m on ground in pixels	10m x 10m on ground in pixels
50 (164)	4384x2466	-20, -20	10 (32)	533	533x533
100 (328)	4384x2466	-20, -20	10	270	270x270
150 (492)	4384x2466	-20, -20	10	174	174x174

Source: Choi-Fitzpatrick and Juskauskas (2015)

Step 4: Grid digitally applied to image – Placing a digital grid over the digital image allows for the rapid estimation of individual unit density and counting of total units. After determining the number of pixels that correspond to the 10 m. reference line, a simple grid can be applied to the picture. A grid application is accomplished in two basic steps using the chosen software (GIMP) and described in Choi-Fitzpatrick and Juskauskas (2015).

Step 5: Estimating the density levels of each grid – With the grid then applied, and with each grid measuring 10 meters between each gridlines, it is now possible to estimate the number of individuals within each grid. Using (Western) density levels established in the literature, we are able to base estimates on five density levels, effectively, where there are no people, where the crowd is very loose, relatively loose, relatively dense, and very dense. Specifically, the five possible density levels are as follows:

Empty (Density Level 0) – A rooftop, or any other empty space, counted at zero.

Very loose (Density Level 1) – A very loose crowd with a very low density level. You could ride your bike through this crowd easily. It is counted manually.

Loose (Density Level 2) – A somewhat loose crowd with a pretty low density level. This is a crowd you could walk through easily without bumping into too many people (imagine about 1 person per square meter). On average, at this density level there are usually about 109 people in the grid. [one person in 10 ft^2 or 0.93 m^2]

Dense (Density Level 3) – This is a dense crowd. You would have a hard time moving through this crowd, but it would be possible (imagine more than 2 people per square meter). On average, at this density level there are usually about 238 people in the grid. [one person in 4.5 ft^2 or 0.41 m^2]

Very dense (Density Level 3) – This is an extremely dense crowd. It would be nearly impossible to move your arms in this crowd (imagine more than 4 people per square meter!). This is the same as the very front of a concert, just in front of the stage. On average, at this density level there are usually about 435 people in the grid. *[NOTE: this density level rarely occurs]* [one person in 2.5 ft^2 or 0.23 m^2]

Step 6: Compile estimate of crowd size – The sixth and final step is counting how many squares of different density levels the grid has. The actual number of the crowd is summed up.

Step 7: Determine intercoder reliability – Some users may choose to incorporate Cohen's Kappa as an optional 7th step in this estimation methodology.

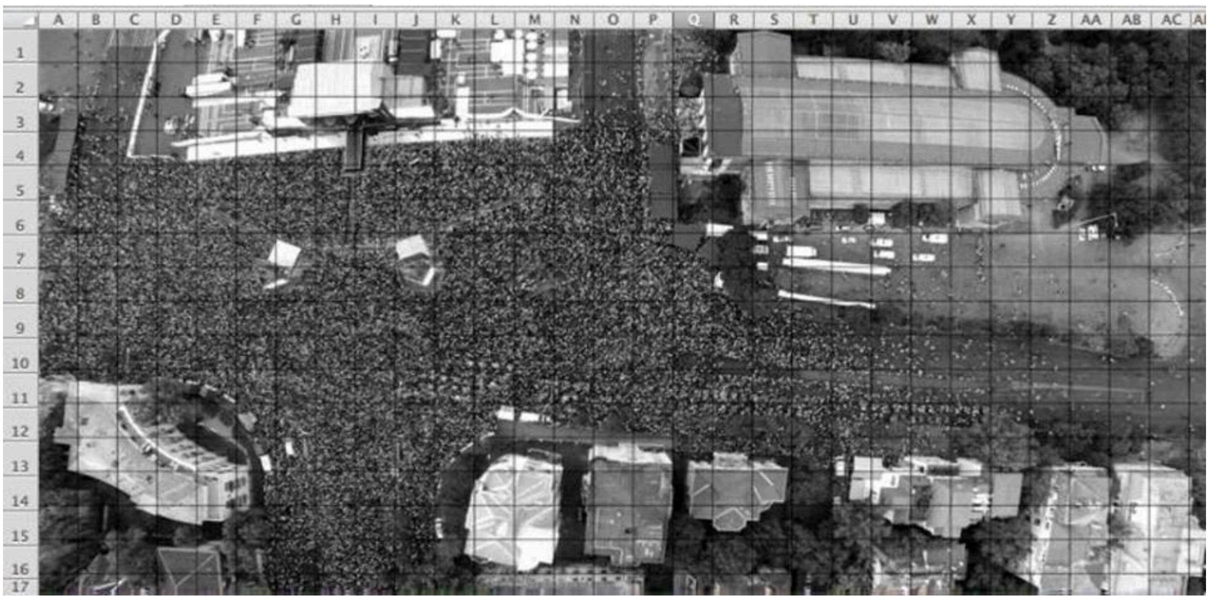
Implementing the Drone-Based Crowd Estimation Model

We applied this method in two public gatherings in Budapest, Hungary. The first was a concert and the other was a protest event. General detail about each event (date, time, weather and GPS coordinates) and specific information regarding estimation parameters (i.e., inter-coder reliability) can be found in Choi-Fitzpatrick and Juskauskas (2015) and briefly in the Appendix.

First Field Test: Concert

The image was made at 160 meters in altitude. Clearly larger crowds will require "zooming out," an action accomplished by increasing the UAV's altitude so that a greater surface area is covered by the image. Prior to photographing the crowd we made the estimation necessary to insert the grid in GIMP. To do this we identified a line that was clearly visible from this altitude. With knowledge of the line's actual length on the ground (15.6m), we used GIMP to measure the pixel length of this referent. The 15.6 meter line on the ground is equal to 237 pixels within the digital photo file. As we need a grid of regular 100 m^2 squares, we need to convert 10 meters into pixels. The formula for determining this ration is described in Section "*Step 3: Area measurements"*. In this case, 10 meter reference equals 152 pixels in the picture. A 10m x 10m square on the ground is therefore a 152px x 152px grid in the image (image 1).

Image 1: Concert event of 36,000 (est)



We recruited research assistants from a cohort of graduate students. Volunteers received a modest voucher (less than 10 USD) and brief verbal introduction to the process and were given approximately 90 minutes to accomplish this task. We found that 80 minutes was the average amount of time required to accomplish this task, and that the instructions led to very few misunderstandings about the task, or any particular step in the task. As detailed in Choi-Fitzpatrick and Juskauskas (2015) coders were instructed to determine the density level within each grid (X, O, 1, 2, 3), to manually count any persons within density level 0, and to then determine what percentage of each grid was filled at the indicated density level (25%, 50%, 75%, 100%). These tasks were accomplished with an 8x10-sized printout of the photograph and a white marker. Coding decisions were made directly onto the image itself.

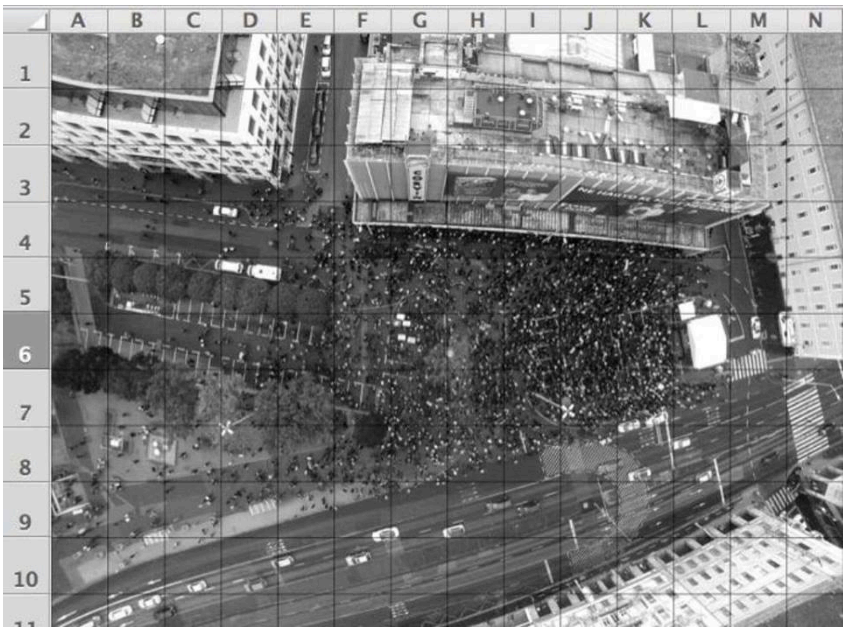
This data was then entered into a spreadsheet by the articles second authors and a Cohen’s Kappa, an industry standard inter-coder reliability estimate, was applied to the data. Our final iteration of the test resulted in an inter-coder reliability estimate of .7 and a crowd estimate of between 37,112 and 37,695. In our own "expert" coding of this data we had determined that there were 36,000 people present at the event.

Who was right? We can here introduce three possible benchmarks for comparison. Each is straightforward. First, ticket sales or turnstile counts: unfortunately for our purposes (but fortunately for concertgoers) this was a free event and neither data points existed. Second, other media sources: several bloggers after the event claimed the event was attended by several tens thousands of people. Third, "indirect passenger volume estimation," such as busses: this event took place close to a public transportation hub, thus rendering easy comparative data is hard to obtain.

Second Field Test: Protest

The second field-test of the method was implemented at a demonstration held by the civil society organization called Human Platform. The event was held during a national holiday and targeted social injustices and lack of democracy in Hungary. In our coding of this data we determined there were 2,609 people present at the event. Using the process described above, external coders (who were unaware of our own estimate) determined that between 2,589 and 3,750 individuals were present, with a Cohen's Kappa of .85.

Image 2. Protest event of 2,000 (est)



While we could have cropped the image to make counting easier, we have left it untouched in order to emphasize one additional question unaddressed by this method: who is part of the event? Who counts? Are the people in squares E3, E4 and E5 part of the event? We can ask the same question of almost everyone in columns 1, 2, 3, 5 and part of 5. Needless to say, it is important to augment the single method of measurement introduced here with observations on the ground, and with comparative benchmarks, where possible. Media estimates of the event size ranged from 700 to 3000. The most frequent estimate was in the 1500-2000 range.

DISCUSSION

Unmanned aerial vehicles are the subject of increasing attention in public, policy and commercial arenas. Yet the bulk of this attention has remained focused on two debates: the first on how the state should regulate UAVs used for commercial purposes, and the second on what should be done about the use of UAVs for military purposes. This essay is meant to provoke discussion in a third area of inquiry and debate related to the use of drones by a broader array of actors. This contribution is timely, as protestors flew drones over Maidan in Kiev during the upheaval that led to the ousting of then-President Viktor Yanukovych, *Russia Today* documented the protests that followed a police shooting in Ferguson, Missouri, and researchers documenting anti-regime protests in Budapest, Hungary, and a South African arms manufacturer has begun shipping “anti-riot” drones equipped with non-lethal armaments, including rubber bullets and tear gas.

These developments raise a number of critical questions regarding the relationship between technology and surveillance. While legislative frameworks are being hastily constructed at the international, national, and sub-state level, such use must adhere to broader ethical guidelines. To this end we follow earlier work (Choi-Fitzpatrick 2014) in advancing a six-fold set of guiding principles for the use of UAVs by civil society actors. While groups such as the American Civil Liberties Union have advanced guidelines, they are predominantly focused on curbing police overreach and the use of drones to violate the positive rights of citizens. In what follows we highlight several themes that policymakers and citizens should consider.

1. Subsidiary – Should drones only be used in those situations where other actions or technology already yield the desired result? New technology can be original without being useful. How might we know the difference?
2. Physical and Material Security – Appropriate measures (training, flight-planning, etc) must be taken to ensure the security of people and things in the

area where a UAV is used. As drone use increases, who will coordinate these efforts? How will anti-establishment actors (e.g., protestors) fit into this space?

3. Do No Harm – This concept, pioneered by Patrick Meier and the UAViator group, emphasizes the importance of the public good: Benefits must outweigh costs and risks. Yet the nature of the public good is a matter of great debate; is Edward Snowden a traitor or a patriot?
4. Newsworthiness – This concept is borrowed from journalism's focus on the greater good and emphasizes the importance of a free press (in both corporate media and citizen journal models) in holding the powerful to account. Must pro-social and advocacy footage only be made "for the greater good" or is aerial data collection important in its own right? Is ubiquitous drone surveillance a simple step up from Google Earth in terms of frequency of coverage or is it a scale shift that represents a fundamental threat to privacy?
5. Privacy – While debates about privacy and technology are ongoing, and users of digital media appear less worried about the issue than advocates, what is the proper balance between the privacy of private citizens and newsworthiness and the public good? Privacy is treated differently across national contexts, and no blanket legislation is possible, meaning the increased use of drones is likely to lead to very different policy approaches.
6. Data Protection – Data protection is critical. Social movements who use camera equipped drones to monitor police action at a political protest, for example, must take great care to ensure that the privacy of protestors is protected and that the digital data is kept secure.

It will be immediately obvious to the reader that some of these criteria are in tension with one another. Should one protect the privacy of a Russian or Hungarian oligarch who has made private millions on secret concessions on public works? It is newsworthy, but documenting private homes, villas and other auspicious wealth raises new questions with regard to privacy (oligarchs have families) and subsidiary (the same information might be gleaned from tax records). The present use can be assessed with this criteria. Doing so suggests that we maintained security, respected privacy, and did no harm while filming a newsworthy event. Whether we passed the subsidiarity threshold is another question: It is possible to measure crowd size without a UAV, though with either greater expense or lesser accuracy. Reasonable people can be expected to disagree on whether we have passed this threshold.

From a technical perspective, the combination of a camera-equipped UAV with a simple but accurate methodology improves on the status quo established by Jacobs and extended by others. This improvement is six-fold. Firstly, with regard to scalability, the method can be used to estimate a crowd of 100 or 100,000. The linking of altitude to square meters of ground cover, and of ground coverage to image pixels is not particularly rocket science, but it does not appear to have been done before. As a result, crowds of all sizes can be measured using this method. Secondly, with regard to cost, the results produced in this study were performed using equipment costing one thousand US dollars at the time of purchase and half that at the time of publication (doubtless a comment on both the youth of the technology and age of this paper!). The same results could be obtained for a third of this amount. This expense pales in comparison to the cost of renting a fixed-wing aircraft or helicopter to perform an estimation of similar accuracy. Third, portability: while it may be too obvious to deserve mentioning, this solution can be deployed from a backpack or carryon-sized luggage. Even more easily deployed technology is available and new devices are quickly entering the market. The fourth benefit, ease of use, relates to the fact that off-the-shelf units such as the one used in this test, and indeed any utilizing GPS capabilities, can be deployed comparatively quickly. The fifth benefit, replicability, refers to the fact that the method we introduce produces comparable data regardless of location, crowd-size, camera dimensions, UAV-type etc. The sixth improvement we bring is in regard to the incorporation of both an inter-coder reliability estimate (as well as a relative standard error term). Together, these benefits combine to recommend this solution to anyone interested in quickly deploying inexpensive equipment to accurately estimate the number of people present in crowds of all sizes.

Listing these benefits should not obscure the complexity involved in using this technique. The entire enterprise raises a host of issues, especially related to privacy and security. As suggested earlier, it is not at all clear how to best balance privacy and transparency, especially when social movements set out to challenge those in positions of authority. This study is an example of innovative use of a new technology in the absence of a policy framework. Regulations devised for an earlier age are unwieldy and ill-matched to new technologies and uses.

Taken a step further, UAVs push a broader question regarding whether privacy is a core collective good, as some have recently suggested (Livingston and Walter-Drop 2014). Any attempt to answer this question will surface deep philosophical divisions between the United States and the United Kingdom and much of continental Europe. Recent recognition of the “right to be forgotten” in Spanish courts has hardly elicited a shrug from Americans actively uploading all manner of content to the cloud, despite the thin guarantees provided on click-through user agreements. While a majority of Americans are pessimistic about commercial and personal drone use, this discomfort will likely decrease with familiarity. The best approach is an ethical approach.

In brief, we believe we have managed to blend old methods with new technology in such a way that respects provisional guidelines for its ethical use. Of course, caveats abound. To begin with, it is important to note that while we have used a quadcopter, this approach should work with both fixed wing UAVs as well as satellites. Also, the method is guided by several main assumptions: the first is that the crowd is static—not going anywhere—which is mostly the case in protests and demonstrations that gather at a particular public place. More sophisticated methods are required to address the flow of crowds found in marches.

Secondly, our methodology assumes individuals are standing on level ground. It is not clear to what extent our calculations would have changed were the ground uneven. Shifting the platform off-center for safety purposes, for example, would increase security but make subsequent imagery harder to inspect visually (“ocular inspection” as some say). Thirdly, we made these images during the day in order to ensure we could capture imagery of discrete individuals. Modifications would be necessary to extend this method to count crowds in low light conditions.[iv]

Additionally, the fact that we developed and tested this methodology in the Global North means we enjoyed an uninterrupted power supply and there was no need to consider power cuts. For countries experiencing a large number of power cuts, or the absence of power altogether, alternative source of power should be considered. Trickle charging from solar or large batteries seems like a reasonable solution, though one that would require additional investigation. Working in Europe there were fewer security issues related to theft of the device. Security may present an issue in more densely populated countries where there might not be as many places suitable for the safe launch and landing of the craft. It may also be that crowds are more dense or loose in other parts of the world. A final consideration when working with this method outside the Global North, but present worldwide at the moment: anonymity is hard when the novelty of UAVs attracts the attention of passersby.

Of course, nothing about the technology prohibits a drone operator from securing footage during ascent and descent, or from navigating the drone through a crowd in an effort to, for example, capture footage of police brutality. The framework introduced here only begins to address the ethical considerations related to the use of this setup for citizen journalism. In sum, this paper proposes a new method for estimating crowd size but does so using technology that can be used for crowd-size estimates as well as the monitoring of protests and protest actors, by either the state or its challengers.

We anticipate these preliminary tests can easily be augmented with more sophisticated methods and techniques. For example, from the very beginning the biggest puzzle for us was area measurements. If area measurements are automated or expressed in an algorithm, it would make things easier. We are confident overhead imagery can be combined with current innovation in the field of computer vision (Ryan 2013) to begin automating the estimation of crowd size. With regard to density, ongoing research has produced more sophisticated methods for estimating density levels. Both issues might be addressed by the development of a mobile application or purpose-built software that could automatize the whole estimation process. Others are also working on the issue of automating the assessment of visual data (e.g., Marana et al 1999; Zhan et al 2008; Ryan et al 2009; Ryan 2013; Kong, Gray and Tao 2005 and 2006), though not from the same platform as ourselves. There is plenty of room for growth in this area.

But what does any of this tell us about social movements? We hope our method will prove useful to those with an interest in the actual size of protests, riots, marches and other politicized mass gatherings. In referring broadly to “those with an interest” we mean to describe police, policy-makers and protestors alike. McCarthy, McPhail, Smith (1996) have established the close link between protest size and media coverage. To date the gap between estimated and actual protest size have fluctuated based on where the location occurred (it’s easier to estimate events in popular locations where prior estimates have been established) and the media’s decision to report police or protesters’ estimates (the latter almost always being higher than the former).

More accurate estimates are not necessarily good news for social movements, who sometimes take advantage of the perception of large events to advance claims. This issue aside, the method frees movements to make their own estimates independent of the state, which is often more likely to possess the resources necessary to produce credible estimates). Additionally, thanks to social media, this information can be easily and instantly uploaded and disseminated. Social movements have the technology, capability and ethical framework to use UAVs in order to ensure accurate and verifiable crowd estimates. Whether they do so is another matter altogether.

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APPENDIX
General Details of Flights

	Test 1	**Test 2**
Date	16th June 2014	23rd October 2014
Time	20:25 (GMT +2)	16:00 (GMT +2)
Weather	+24, clear	+10, rainy
Wind	5 km/h	4 km/h
GPS	9 satellites	10 satellites
Altitude	160 m.	80-90 m.
Take-off	Heroes square, Dozsa Gyorgy Way, south-east side	Blaha Lujza Square, Budapest
Reference (px)	10 m (152 px)	10 m (308 px)
Grid square (px)	100 m^2 (152x152 px)	100 m^2 (308x308 px)
Total number of people (est)	36,000	2,609
Cohen's Alpha Intercoder reliability	.73	.85

Endnotes

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[i] One can think of moments when collective action makes claims visible without the physical presence of large numbers of protestors. Striking sanitation workers bring attention to their vital social role by simply staying at home.

[ii] We prefer the term "remotely piloted aerial platform," as it reflects the wide range of payloads and the reality of a pilot (of any gender). While we would be happy if this phrase became popular, we have chosen to use industry-standard terms here.

[iii] When purchased, small consumer drones ranged in price from approximately $300 to around $3000. This device was purchased for $1000.

[iv] Presumably, future work could incorporate infrared cameras rather than traditional RGB cameras to capture images that are amenable to the same methodological treatment.