Progress in Human Geography 29, 5 (2005) pp. 562–580

Software-sorted geographies

Stephen D.N. Graham

Department of Geography, Durham University, Science Site, South Road, Durham DH1 3LE, UK

Abstract: This paper explores the central role of computerized code in shaping the social and geographical politics of inequality in advanced societies. The central argument is that, while such processes are necessarily multifaceted, multiscaled, complex and ambivalent, a great variety of 'software-sorting' techniques is now being widely applied in efforts to try to separate privileged and marginalized groups and places across a wide range of sectors and domains. This paper's central demonstration is that the overwhelming bulk of software-sorting applications is closely associated with broader transformations from Keynesian to neoliberal service regimes. To illustrate such processes of software-sorting, the paper analyses recent research addressing three examples of software-sorting in practice. These address physical and electronic mobility systems, online geographical information systems (GIS), and face-recognition closed circuit television (CCTV) systems covering city streets. The paper finishes by identifying theoretical, research and policy implications of the diffusion of software-sorted geographies within which computerized code continually orchestrates inequalities through technological systems embedded within urban environments.

Key words: CCTV, code, geodemographics, inequality, mobilities, remediation, software-sorting, surveillance, unbundling.

I Introduction: code and the remediation of inequality

> The modern city exists as a haze of software instructions. (Amin and Thrift, 2002: 125)

> Values, opinions and rhetoric are frozen into code. (Bowker and Leigh-Star, 1999: 35)

Computer software mediates, saturates and sustains contemporary capitalist societies. Enrolled into complex technoscientific and machinic systems, stretched across time-space, a vast universe of code provides the hidden background to the functioning and ordering of such societies (Lessig, 1999). The flows, mobilities and transactions; the folded geographies of inclusion and exclusion; the construction, consumption and experience of place; the very operation of distanciated webs of production, distribution and consumption – all, very literally, are now *performed*, at least in part, through the continuous agency of vast realms of computer software.

With computerized systems now actually becoming the 'ordinary' sociotechnical world in many contemporary societies (Amin and Thrift, 2002), code orchestrates a widening array of public, private and public-private spheres and mobility, logistics and service systems and spaces. This new 'calculative background that is currently coming into existence', as Nigel Thrift describes it (2004a: 582), is based on ubiquitous, pervasive and

 10.1191/0309132505ph568oa

interlinked arrays of computerized spaces, systems and equipment which increasingly blend seamlessly into the wider urban environment (Cuff, 2002). Such technosocial complexes of code, and their supportive hardware and organizational systems, have variously been described in terms of a kind of 'immanent domain' (Cuff, 2002), 'ubiquitous computing' (Hunter, 2002), an 'invisible city' (Latour and Hermand, 1998), a 'surveillant assemblage' (Haggerty and Ericson, 2000), or a proliferating array of 'Automated Socio-Technical Environments' (Lianos and Douglas, 2000). However one describes them, code-based technologized environments continuously and invisibly classify, standardize, and demarcate rights, privileges, inclusions, exclusions, and mobilities and normative social judgements across vast, distanciated, domains (Bowker and Leigh-Star, 1999; Thrift and French, 2002; Graham and Wood, 2003; Thrift, 2004b).

Given all this, it is curious that remarkably little attention had been paid to 'the millions of lines of code that have come to run cities, as computing power has increased and as many former bodily practices have been written into code' (Amin and Thrift, 2002: 125). What Nigel Thrift and Shaun French (2002: 309) term the *automatic production of space*, through the simultaneous enaction of multiple, interacting worlds of computer software, remains largely ignored in human geography and social science more generally. Sunk in the taken for granted background of everyday life, these worlds of code exert their power over the geographies and lifeworlds of capitalism continuously and powerfully, but with scarcely any analytical or day-to-day scrutiny. This invisibility contrasts markedly with the burgeoning library of volumes which now exist addressing the connections between new technologies and urban life more generally (Graham, 2004a). Thus, it seems, 'code is in some sense invisible compared with its computer carapace' (Amin and Thrift, 2002: 125).

As the opaque and esoteric worlds of code operate to directly shape the practices and possibilities of everyday life in ever-extending ways, so the analytical challenge is thus to excavate the worlds of code as critical political, social and geographical sites requiring urgent understanding, regulation and intervention. 'Software challenges us to understand new forms of technological politics and new practices of political invention, legibility and intervention that we are only beginning to comprehend as political at all' (Thrift and French, 2002: 331).

Encouragingly, a range of recent work in geography, sociology, technology studies and allied disciplines is starting to make real progress in unearthing the ways in which contemporary capitalist societies are continuously brought into being through code. Such work reflects a broad shift in social scientific analyses of new media and information technologies. Here, attention has turned away from discussions suggesting that such technologies offer access to some 'virtual' domain which is somehow distinct and separable, in some binary way, from the 'real' spaces and places of cities and material urban life (Woolgar, 2002). In their place, much more nuanced and sophisticated approaches are emerging. These stress that new technologies are intimately involved in the fine-grained and subtle transformations, or 'remediations', of place- and space-based social worlds (Bolter and Grusin, 2000; Haythornwaite and Wellman, 2002; Graham, 2004a; 2004b). Far from being separated domains, then, such perspectives underline that the coded worlds of the 'virtual' actually work to continually constitute, structure and facilitate the place-based practices of the material world (Dodge and Kitchin, 2004: 198). Castells (1996: 373) calls this the shift from 'virtual reality' to 'real virtuality' (see Dodge and Kitchin, 2004).

The purpose of this paper is to provide a critical review of emerging work on the relationships between the worlds of code and human geography. This is undertaken as a means of taking stock of this emerging body of work and to suggest directions for future research. The specific focus here is on the ways in which software code actively shapes and structures social and geographical inequalities within and between places in a wide variety of ways. In what follows, I review emerging research which addresses three particularly important domains where social and economic inequalities within and between places are directly mediated, and shaped, by hidden worlds of code. These address, in turn: spaces of physical and electronic mobility, the production and consumption of urban neighbourhoods via online geographical information systems (GIS), and the growth of facial recognition based closed circuit television (CCTV) covering city streets. Before reviewing these three bodies of work, however, it is necessary to place coded geographies of inclusion and exclusion within their wider political economic contexts.

II 'One person's infrastructure is another's difficulty': software-sorting and political economies of 'unbundling'

To capture the ways in which software code mediates contemporary social worlds automatically (i.e., with little immediate human supervision), with very little delay (i.e., in real time) and continuously, I coin the term 'software-sorting' (Graham, 2004c). Software-sorting is a critical landscape of power within what Jeremy Rifkin (2001) has termed the 'age of access'. Rifkin uses this term to describe the way in which individual and collective life chances are shaped increasingly by their treatment within computer-controlled, customized, service domains. These, Rifkin argues, are increasingly orchestrated through technological networks which are structured to operate automatically using consumerist criteria. Such systems enrol selected, privileged users while precisely controlling access for those deemed unprofitable, risky or deviant.

Software-sorting is the means through which such selective access is organized (Graham and Wood, 2003). Such processes operate through a vast universe of what Michel Callon (1986) has termed 'obligatory passage points'. These are particular topological spaces within sociotechnical systems through which actors have to 'pass' in order that the system actually functions in the way that dominant actors desire. The obligatory passage points within software-sorting systems involve a burgeoning array of subscriptions, passwords, service entitlements, physical and virtual access control points, electronically surveilled passage points and transaction systems, automated, biometric judgements, and normative databases – all of which are continuously enacted and sustained through code and computerized systems based on machine-readable inputs (see Lyon, 2003a; Dodge and Kitchin, 2005).

The term software-sorting captures the crucial and often ignored role of code in directly, automatically and continuously allocating social or geographical access to all sorts of critical goods, services, life chances or mobility opportunities to certain social groups or geographical areas, often at the direct expense of others (Lyon, 2003b). It is crucial to stress, then, that the 'mobile publics' inhabiting the extending neoliberal geographies of flow and access that are the focus of so much recent work in geography, anthropology and sociology (Cresswell, 2001; Lyon, 2003b; Sheller, 2004) are publics that are often prioritized, enacted and kept apart by hidden worlds of software-sorting.

Crucially, however, the links between software-sorting and geographical inequalities are inherently complex, ambivalent and ambiguous. This is for at least five reasons. First, the geographical and social configurations of software-sorted service or mobility systems vary dramatically and may support or entail diverse restructuring dynamics. As the next section of this paper underlines, such techniques facilitate a wide range of restructuring and innovation processes across a very wide range of service and material domains and spatial scales. While there may be similarities, each of these will have its own particular social and geographical configurations and dynamics.

Secondly, the application of software-sorting systems is far from being some simple, deterministic or one-dimensional technological or political-economic shift. Attempts at using software-sorting techniques to support the separation or secession of certain groups from wider, more public, domains, for example, are never simple, 'top-down' and dualistic. Transgressions of categories are almost always possible; asserted boundaries are almost always porous to some extent (see, for example, Bloomfield, 2001).

Thirdly, the application of software-sorting techniques is never simply about the structuring and maintenance of social and geographical inequalities *per se*. They are also often closely enrolled into wider processes of identity and difference (re)formation, as processes of consumption are shaped and enrolled by subjects to support wider constructions of place, difference, mobility and identity.

Fourthly, and as we shall see in this paper's conclusions, software-sorting techniques are nothing if not flexible: they can be shaped to sustain highly empowering, progressive and environmentally positive service innovations as well as highly regressive ones.

Finally, it is important to remember that complex inequalities were always a feature of the service regimes that predated the introduction of software-sorting techniques. The discursive egalitarianism that tended to characterize Keynesian or monopolistic service and infrastructure regimes, for example, often tended to contrast sharply with their highly unequal material effects 'on the ground' (Graham and Marvin, 2001). So we should be careful not to romanticize or overemphasize the egalitarian achievements of the modern, Keynesian models of service and infrastructure provision, based on electromechanical technologies and bureaucratic information systems, that are being complemented or replaced by software-sorted systems.

While taking these caveats on board, this paper demonstrates that a particularly important feature of the current wave of software-sorting applications is their direct enrollment to help restructure and recommodify many previously 'public' domains of everyday life and material culture within western capitalist nations. While they are inherently multitudinous, diverse and ambivalent, and operate at multiple scales, the predominant dynamic of contemporary software-sorting innovations seems to be linked closely to the elaboration of neoliberal models of state construction and service provision (Graham and Marvin, 2001). Without software-sorting techniques, for example, many major infrastructural and material transformations, based on the application of neoliberal political paradigms and ideologies to a wide range of social and economic contexts, would be all but impossible. Examples include electronic road pricing, 'bypass' immigration based on biometric IDs, 'virtual' and competitive electricity markets, Internet systems where the 'packets' of data are individually prioritised, online geodemographic consumption systems, facial recognition closed circuit television on city streets, and electronic tagging systems for low-level offenders. While acknowledging the inevitable flexibility associated with software-sorting techniques, it is therefore apparent that their widening application needs to be seen as a crucial, facilitating dimension in the broad shift from Keynesian welfare states and public domains to 'splintered', post-Keynesian regimes of infrastructure, service, and space production and consumption (Graham and Marvin, 2001; Brenner, 2004).

Lianos (2003: 424) argues that such transitions involve broader processes of *desocialization*. In these, discourses or paradigms emphasising universal or quasi-universal rights of access or consumption, based on Keynesian ideas of citizenship, cross-subsidy, monopolistic control, universal service, and electromechanical or bureaucratic technologies, are often replaced – or at least complemented – by new software-sorted modalities of power. Often intensely individualized and commodified, the immense transactional flexibility and surveillance power of software-sorting means that the essential infrastructures, spaces and services of everyday can thus undergo a process of 'mass-customization' (Andrejevic, 2003) or widescale 'unbundling' (Graham and Marvin, 2001).

Very often, then, software-sorting techniques are being used to undermine some of the classic characteristics of urban public goods,[1] allowing at least some of these limits to recommodification to be reconfigured or even swept away (Pinch, 1985). Packaged, delivered through consumerist markets, sorted through the endless distinctions of geodemographic profiles, and linked closely to the surveillance of actual consumer behaviours, market potentials or desires, fully unbundled service and access packages thus become possible. Under pressure to maintain or increase profits, within the context of widespread privatization and liberalization, service packages geared towards more lucrative market niches can thus be customized and 'splintered' from the wider societal fabric though software-sorting techniques (Graham and Marvin, 2001; Andrejevic, 2003). At the same time, less lucrative users of streets, mobility systems, services, electronic communications grids, and places can be electronically (and/or physically) pushed away and marginalized, either absolutely or relatively, through software-sorting and machinations of code.

Such processes of unbundling can thus allow targeted users to enjoy enhanced mobility, reliability, service quality, quality of life, or (real or perceived) freedom from risk, crime, congestion, or contact with (sometimes demonized or humiliated) Others (Young, 1999). 'The mobility of some can', in short, be reconfigured to 'immobilize others' (Cresswell, 2001: 21). 'One person's infrastructure' can become 'another's difficulty' (Leigh-Star, 1999: 390). Crucially, however, because most processes of software-sorting are actually invisible from the point of the users, these prioritizations are often not evident either to the favoured groups or places or to the marginalized ones.

III Code space: software-sorted mobilities

With these points in mind we can turn to our three reviews of particular software-sorted geographies. Our first – that of software-sorted physical and electronic mobility systems – remains perhaps the least understood and researched. Considerable work has been undertaken exploring the ways in which complex assemblages of new technologies facilitate and mediate a whole range of mobilities (Urry, 2000). The blurring of new media into car systems (Sheller and Urry, 2000; Thrift, 2004c), logistics systems (Meyer, 2001), airport systems (Aday, 2004a; 2004b; Dodge and Kitchin, 2004a; 2004b), and street spaces (Andrejevic, 2003) has been increasingly reported. However, the specific roles of software-sorting systems in shaping social and geographical inequalities in physical and electronic mobility systems and spaces remain only poorly understood.

It is clear that physical mobility systems increasingly utilize powerful software-sorting techniques to address imperatives of profit maximization, social control, or perceived risk minimization. Emerging research by Aday (2004a; 2004b) and Dodge and Kitchin (2004), for example, has successfully revealed the ways in which key physical mobility spaces such as airports can only sustain the astonishing transactional complexity now expected of them because they are saturated with, and, indeed, constituted through, complex sets of software-sorting and coding systems. Importantly, Dodge and Kitchin (2004: 198) argue that the relationship between code and electronic and physical mobility systems like airports is qualitatively different from the relationship between code and other types of built or technosocial environment. With mobility systems they write that 'the relationship between code and space is *dyadic* – code and space are mutually constituted, wherein how the space is produced and used is predominantly mediated by code' (original emphasis). Dodge and Kitchin use the term 'code/space' to describe such environments. This they distinguish from 'coded spaces' like CCTV-surveilled streets, where code remains, thus far, more peripheral to the constitution of the built environment (2004: 198).

1 Software-sorted airline mobilities

Taking airports as paradigmatic 'code/spaces' and sites of ubiquitous tracking, it is now clear that 'the control of international mobilities that cross *through* airports and border zones are effectively managed, filtered and screened *within* these sites' (Aday, 2004a: 1365, original emphasis). This work demonstrates that, traditionally, the use of machine-readable tags and tickets allowed all human, cargo, baggage and worker flows in and around airport spaces, and, indeed, airline systems, to be surveilled, tracked, and socially controlled with a high degree of precision. As computerization of the multiple logistical and transactional systems involved has proceeded, so an extending universe of software and code has started to orchestrate the burgeoning flows associated with the global airline system.

Importantly, from the point of view of software-sorting and social inequality, Aday (2004a) shows that such systems are being augmented by software-sorting systems where the identifier of a person is actually biometric – that is, a supposedly unique signifier scanned directly from part of the human body (usually a finger, face or iris scan). Initially – as at Schipol airport's 'Privium' system – biometrics have been used to allow 'premium', business travellers to bypass conventional border controls. Aday argues that the practices and framings of biometric approaches to software-sorted mobilities are deeply shaped by neoliberal ideologies. In particular, a politics of differential speed is established. Biometric techniques are used to 'facilitate the ease of speed for trusted, "good" and economically sound business travellers and yet impede the flow of "bad guys" or secondary processing – where officers "really don't care how long it takes" to process their entry' (Aday, 2004a: 1370).

However, as biometrics shift from élite to mass usage, the prospects of travellers who are not able to display their body's signature – 'illegal' migrants or asylum seekers, for example – worsen considerably. This is because the identification and tracking of such people will become much easier simply because they are subjects attempting to travel around the world's airline system *without* their associated data image or biometric tag moving through the parallel, coded system.

Compounding the routine racial profiling or air travellers, which has deepened significantly since 9/11, biometric software-sorting techniques necessitate a massive global extension of interconnected databases, in order to match the deep association of bodies, flows and information at transnational scales. The diffusion of such techniques underline the fact that, as Aday concludes, 'the airport is now a surveillance machine – an assemblage where webs of technology and information combine. Movement, and, increasingly, the body, identity, and objects are made legible, momentarily fusing with technology and virtual realism' (2004a: 1375).

2 Unbundling public roadspace monopolies: the quest for 'real-time' road pricing

Highway and urban transport systems are facing similar transformations (Graham and Marvin, 2001). For example, in a detailed case study of the construction of the world's largest privatized, electronically charged highway system – the CityLink in Melbourne – David Holmes (2000) has underlined how scarce urban road space can become a priced commodity allocated to those who can afford it through software-sorting techniques. While, like the central London congestion charge, access here is controlled through a fixed tariff, in some premium highways in California – for example I-15 highway in

San Diego – software-sorting can actually display variable pricing in real time (Graham and Marvin, 2001: 253). This is based on algorithms which estimate exactly the level of price per journey that is likely to deter enough drivers to guarantee free-flowing traffic – no matter how bad the congestion is on the surrounding public highway system.

Here we confront software-sorting to guarantee speed, and time saving, to those able and willing to pay for technoscientific, urban bypass, using a 'premium' roadspace, on a per-journey basis. Such techniques herald new inter- and intra-urban geographies of differential mobility. In these, transponders and private, premium road spaces are enrolled, along with the capsular architectures of automobiles themselves, to allow consumerist markets of road space to be constructed within, through, and on top of pre-existing, public roadspace monopolies.

More promisingly, software-sorted automobilities may also support broader reconfigurations of automobile systems, based on forcing drivers to confront, and pay for, the direct social and environmental consequences of their choice of vehicle. If EU proposals for satellite-based charging of all road users are ever implemented, for example, software-sorted techniques could conceivably be used to force drivers to pay charges based on assessments of the precise environmental externalities of their vehicles (see Foley and Fergusson, 2003).

3 The Internet: from 'best effort' to 'squelching the scavenger class'

Remarkably similar techniques are also being mobilized, much more discreetly, to sort people's access to a whole suite of electronic mobility, communications, and service systems (Winseck, 2003). The Internet, for example, was originally developed to accord all the 'packets' of information that flowed within it equal status. This was the so-called 'best effort' model of packet switching where equal efforts were made to allow all packets to flow to desired destinations at all times. Now, however, the Internet is being re-engineered into a corporately controlled system of systems dominated by a vast range of commercial services. As Dwayne Winseck notes, the technological architectures of the Internet are thus being reconfigured:

> by designing networks that put intelligence, resources, and capabilities back in the network .... Consequently, open network architectures are yielding to network designs that enhance network providers' ability to allocate resources, bandwidth, and speed to varying types of information and services. This is based on their relation to the network owner, revenue potential, class of user served, and judgements regarding the quality of content. (Winseck, 2003: 182)

In the process, complex software-sorting techniques are now being enrolled, by the transnational media firms who run the Internet, to actually sift and prioritize each of the billions of data packets that flow over the net at any one time. While this will allow a guaranteed quality of service to 'premium' users and prioritized services, even at times of major Internet congestion, those packets deemed unprofitable will actually be deliberately 'dropped', leading to a dramatic deterioration in the electronic mobilities of marginalized users or non-prioritized services (Graham, 2004c). Such strategies are closely linked to the growing corporate control of domestic and mobile Internet use, where 'home portals' and coded 'cookies' establish an increasingly commodified regime through which multimedia conglomerates capture personal identities, enrolling them into coded geographies of marketing and exchange, often without users' knowledge (Luke, 2002).

Take, for example, the strategy of the most important manufacturer of Internet routers, Cisco (2002). They have produced a telling document outlining the centrality of software-sorting to the new Internet architectures that they are establishing. Describing how premium Internet services can now be offered to what they call the 'transactional/interactive data class' of users, the document also outlines how the electronic mobilities of what they term the 'scavenger class' will now be actively *impeded* based on software-sorting of every single Internet packet. 'The Scavenger class [categorization] is intended to provide differential services, or "less-than-Best-Effort" services, to certain applications', the document suggests. 'Applications assigned to this class have little or no contribution to the organizational objectives of the enterprize … Assigning a minimal bandwidth queue to Scavenger traffic forces it to be squelched to virtually nothing during periods of congestion' (Cisco, 2002).

Such techniques might clearly allow the vast volumes of unsolicited spam to be systematically marginalized on the Internet. However, a major concern is that Internet users deemed to be insufficiently profitable to serve for whatever reason will also face a growing relative, or absolute, marginalization, without even being aware of it, as their very packets are actively slowed down or dropped altogether through software-sorting techniques.

Such potent 'netscapes of power,' as Winseck (2003) terms them, are completely at odds with the widespread surviving perception that the Internet somehow intrinsically embodies deeply egalitarian exchange. 'Far from being transparent means of channelling information from one point to another,' writes Winseck, the emerging software-sorted Internet networks 'are technologies of discrimination that regulate information flows according to fine-grained criteria set by network owners. In essence gatekeeping functions have been hardwired into network architectures as part of the communication industries' strategies to cultivate and control markets' (2003: 1820).

Similar software-sorting techniques have also been shown to shape the results produced by supposedly unbiased search engines in ways that favour the affiliates of the transnational media conglomerates who own search engine companies (Introna and Nissenbaum, 2000). Moreover, as mobile phones emerge as peripatetic appliances mediating user's relationships with geographic and city spaces and services, so they, too, are opening up whole new realms of software-sorting (Andrejevic, 2003). Here, such techniques promise to customize 'mobile commerce' services to detailed records of an individual's own consumption and mobility habits, targeting advertizing spam for goods and services that are geographically and geodemographically appropriate, as the user moves around the city. Individually tailored city maps will be directly customized to software records of users' consumption habits. Andrejevic points out that 'time-space paths will be used as a strategy for customization. Advertizing and marketing appeals will be directed to consumers based on where they are in time and space.' This, he believes, will usher in 'a radical departure from the productive disciplinary surveillance associated with the institution of mass society' (2003: 134).

4 Call centres: the politics of differential queuing

In our final example of software-sorted electronic mobilities, it is becoming apparent that even call centre telephone queues are now being differentially sorted based on value judgements about callers' economic value as customers (Graham, 2004c). Because call centres can detect the telephone numbers of incoming calls, and instantly check these against customer and geodemographic databases, they can use software-sorting techniques to queue 'good' customers for much shorter times than 'bad' customers.

'One of your best customers dials the national customer service number for your company', gushes the scenario in a marketing brochure from the Avaya Corporation (2000), a major manufacturer of call-centre systems. 'The ANI [automatic number identification] database reveals the customer to be among the top 5% of your customers. [Our system] routes the customer at high priority. When the agent picks up the call, he hears a whispered announcement that this caller is "Top 5"' (2000: 3).

IV Code place: software-sorted cities

A substantial body of research has revealed the importance of geographical information and geodemographic systems (GIS and GDIS) in shaping the production and consumption of contemporary urban spaces (Goss, 1995; Curry, 1998; Phillips and Curry, 2003). With their tendency to exaggerate and reify homogeneously constructed 'ideal type' neighbourhood profiles, and so to ossify spatial and social classifications, such techniques have been widely shown to underpin redlining and socially regressive location decision-making and service planning (Pickles, 1995).

1 Geographic information systems as urban surveillant-simulations

GIS and GDIS do indeed provide powerful urban software-sorting devices. Here code is used both to surveil the social geographies of cities and provide the means to construct powerful, and often highly biased, simulations and visualizations of those geographies (Graham, 1998). Unlike the software-sorted mobility systems just discussed – and those operating on public streets that we shall shortly address – geodemographic systems do not, yet, offer real-time mediations of cities and urban life. Rather, they are systems of surveillance and simulation that rely on what Phillips and Curry (2003) have called a 'phenetic fix'. Linked to locational referencing, postcode databases, mobile and electronic commerce systems, and geopositioning networks, this palimpsest of code is increasingly determinate in support self-reinforcing spatial categorizations. In the process, 'databases become increasingly determinate: you become where you live' (Amin and Thrift, 2002: 45).

Thus the city thus itself becomes a software-based simulation, a fine-grained dynamic map of consumption and spending potential, as the large geodemographic bureaux now attempt to capture more and more direct consumption information into GIS-based 'data warehouses' from store credit cards, credit bureaux, direct marketing campaigns, Internet responses and the like (Graham, 1998). Goss (1995) outlines how such GIS-based systems become transformed from partial representations and simulations of some putative 'reality', to effectively operate as *reality itself*, the basis for precise locational decision-making and profit-driven targeting within large retailers:

> the GDIS (Geo-Demograpic Information Systems) is literally represented as a construction, a 'built environment' consistent, of course, with the architectonic metaphors so pervasive in the discourse on information technology. This architectonic metaphor effectively gives substance to a language, reifying the binary code that represents information as an alternate world, literally a data 'structure' … The abstract data structure is then anchored to a direct representation of reality, which leads to the conceit that the world of the GDIS is itself another reality … A representation of the 'exteriority' of the world is interiorized on the computer. (Goss, 1995: 143–44)

2 Online GIS, software-sorting, and the remediation of neighbourhoods

Crucially, however, Roger Burrows and Nick Ellison (2004) have demonstrated that the reach and power of GDIS is now extending to directly shape the consumption of neighbourhoods, the processes of individual and collective identity formation, and the dynamics of housing markets and educational systems, in extremely powerful ways. Increasingly, GDIS and GIS-based representations of city spaces are directly mediating the consumption of place through software-sorting systems that can be accessed directly by consumers. Burrows and Ellison (2004: 326) argue that 'the informatization of neighbourhood consumption that online GIS websites of various sorts make available provides the informational resources by which strategically inclined social groups are able to find "their" place within complex and dynamic urban spaces'.

As GIS emerge to dramatically remediate the consumption of housing, education and all manner of geographically specific services and attributes (at least for such 'strategically inclined' groups), so the processes of neighbourhood informatization take a crucial new turn. Comprehensive national websites like upmystreet.com in the UK provide powerful postcode-based searching devices through which coded algorithms deliver multidimensional analyses of everything from crime rates, school performance, house prices, environmental quality, hazards, and pollution to access to services. Customized maps and aerial photographs can be accessed, and virtual communities of 'like-minded' people living in the neighbourhood can be accessed. In the USA such processes have gone even further. Using websites like homestore.com, people considering moves can automatically sort through metropolitan social geographies to find neighbourhoods with the social and demographic profiles that most closely 'match' those of their current location.

The current saturation of urban environments with a vast universe of tracking systems means that, very soon, dynamic and real-time geographical simulations of urban places will be accessible over the Internet. These attempt to match the social and demographic fluctuations of real places over various temporal scales (Burrows and Ellison, 2004: 329). Once such 'tracking' – of people, vehicles, consumption habits, and digital interactions – becomes routine, software-sorting techniques will move beyond crude, generalized, and 'lumpy' simulations of places accessible over PCs, to offer real-time and fluctuating simulations to mobile and hand-held computers based on the real time-space flux of urban mobilities. Such systems will allow individuals to be 'aggregated with that of other proximate mobile individuals in order to construct fleeting geodemographic characterizations of any particular configuration of people in any particular place' (Burrows and Ellison, 2004: 329).

As a result of such applications, it is now clear that the social politics of place, and the geographies of urban inequality, are being directly mediated by the sorting and simulation capabilities of online geodemographic software. The individual and collective preferences, and identities, of subjects are starting to impact upon the geographies of inequality through their active engagement with software-sorting systems. Through such systems 'privileged social actors increasingly affect the social and political patterning and characteristics – and social politics – of their chosen neighbourhoods' (Burrows and Ellison, 2004: 334). Online GIS are being used to negotiate the social geography of cities. Such systems:

> strategically substitut[e] online search capacity for what was hitherto intuition … The use of information for ostensibly consumption and lifestyle goals will transform the contours of social citizenship. Essentially, individuals who are privileged in this way can be expected to separate themselves increasingly from a dependence of goods and services produced for collective ends – and, by extension, from the responsibilities that accompany these forms of collective consumption. (Burrows and Ellison, 2004: 330)

Thus, as online GIS support a consumerization of the consumption and production of urban social geographies, the real concern is that such processes will further support an unbundling of notions of universal urban citizenship that elsewhere, in my book with Simon Marvin, I have termed a process of 'splintering' urbanism (Graham and Marvin, 2001). Individualized, online-GIS-based decisions and behaviour, based on self-identities and reflective, lifestyle choices, are likely to allow socially powerful groups to further their secession from the wider space-times of the city, as they seek to locate in, and consume, the privileged, best serviced and highest amenity neighbourhoods. The algorithms that support such choices, simulations, orderings, and classifications – the very guts of online GIS systems – meanwhile remain completely opaque and utterly unscrutinized. Moreover, 'aside from the initial programming of these systems and the naming of the classifications they use, there is little human agency at play in their day-to-day operation' (Burrows and Gane, 2004: 29).

When added to the proliferation of privatized mobility infrastructures and defensive, gated, private communities in many cities, the predominant use of online GIS by relatively affluent, powerful and technologically literate groups seems likely to provide new 'secessionary networked spaces' (Graham and Marvin, 2001). These seem likely to work to further undermine concepts of universalized, redistributive politics based on integrative and public notions of city governance operating to ameliorate social inequalities across metropolitan scales. This is particularly so as marginalized subjects and communities in cities often remain largely unable to engage in the online GIS that are so rapidly remediating the production and consumption of urban places for more affluent groups. 'Lacking the requisite virtual and material resources, these groups are less able to shape forms of social politics capable of protecting, let alone extending, the public services and accompanying collectivist ideologies on which they continue to depend' (Burrows and Ellison, 2004: 335). Such conclusions, however, must remain speculative because very little research has actually yet been done on the ways in which online GIS systems are influencing the production, consumption and experience of geographies of urban inequality.

V Code face: software-sorted streets

Our final exploration of the extension of software-sorting techniques addresses the proliferation of 'algorithmic' closed circuit television systems, covering city streets and public places, which attempt to automatically recognize people's faces using inputted image databases. Building on the massive and rapid diffusion of analogue CCTV, which relies on the (expensive) 'MK1 eyeball' of human operators scanning monitors and recording footage using banks of domestic-style video recorders, a major effort is now being made to replace such systems with much cheaper, automated, facial recognition, or 'event-driven', CCTV (Norris and Armstrong, 1999). Often such systems take advantage of the installation of broadband and Internet infrastructures with their ready multimedia capabilities. The 'surveillance surge' that has followed the 9/11 attacks, as a vast 'security-industrial complex' has attempted to sell 'silver bullet' technologized solutions to the perceived fears of 'terrorism,' has added further momentum to the digitization of CCTV (Gray, 2003; Zureik, 2004; Lyon, 2004).

1 The face as barcode: face-recognition CCTV and the automation of street surveillance

In digital, facial recognition CCTV, the software-sorting process involves the inputting of the facial, biometric imagery of a 'target' population which computer algorithms then actively seek out. Crucially, this inputting tends to go on without the subject's consent: 'unlike other biometrics [facial recognition CCTV] can operate anonymously in the background' (Koskela, 2003: 2). The code within the facial recognition system becomes a key political site because its operation automatically stipulates the subjects, locations or behaviours that are deemed by the operators to be 'abnormal', 'threatening' and worthy of further scrutiny or tracking.

As well as stipulating the digitized signatures of 'target' faces, software-based CCTV can also be programmed to search for the signature walking styles that are deemed to be most often used by those committing criminal acts, for the number plates of suspect cars, even – when linked with microphones or smelling sensors – for stipulated, suspect, sounds or smells (Hook, 2001). One report on the growth of such automated, 'intelligent', detection systems, from a leading CCTV industry representative, bluntly explains the process through which software is designed to 'target' apparently 'abnormal' behaviours, presences, and people. 'Recognizing aberrant behaviour', it writes, 'is for a scientist a matter of grouping expected behaviour and writing an algorithm that recognizes any deviation from the "normal"' (Hook, 2001: 20).

The social politics of software-sorting are rarely described so succinctly. The report continues to describe how pattern-recognition and neural software could be embedded within facial recognition CCTV to support a much wider automated search for the supposed signifiers of social pathology. 'If the sensors were to "see" a leg moving back and forward but the torso remaining still,' it continues, 'that might suggest that someone was kicking something rather than just walking along. Equally, a milling crowd where none was expected or rapid movements of an arm might also trigger an alarm in the system' (Hook, 2001: 20).

The fact that coded algorithms can automatically monitor vastly larger domains of time and space, and dramatically larger CCTV camera networks, than human operators adds to the sense that it represents a step-change in the power of CCTV (Graham and Wood, 2003). There are very real risks that the multiple 'islands' of private and public CCTV systems, each monitored by its own human operators, could quickly merge into much more massive and geographically stretched facial recognition CCTV systems. Potentially, these could operate to exploit transnational divisions of labour, with operators, and their software-sorting systems, on the other side of the world from the CCTV 'eyes' themselves. Software-sorting techniques provide scope to realize the clear economies of scale and scope that the obvious limits of human operation have, thus far, made impossible (Graham, 2002).

The proliferation of such systems raises a host of crucial political, social and ethical questions. The possible connections between facial recognition CCTV and the geographies of inequality are particularly worrying. What happens, asks Phil Agre (2001), when a person's face becomes a sort of 'barcode' that is captured without their permission, and integrated into vast databases allowing extending and interconnecting facial recognition systems, potentially, to track their movements continuously? 'As the technology advances', writes Mitchell Gray (2003: 216), the clear risk is that 'the software will effortlessly track individuals moving through urban space, public and private. Any appearance of a person deemed threatening can be set to trigger an alarm, assuming that that person's face has been recorded in a linked database'.

However, such fears must be balanced by the real problems involved in making facial recognition CCTV work on city streets even at a very local scale. Most trials of facial recognition CCTV have tended to operate within the narrow obligatory passage points of airport security checks and access control systems. Translating such systems to the open and extremely porous domains of city street systems – with people's facial images complicated by multiple angles, weather conditions, levels of light, changing facial appearances, and human ageing – is a major headache for digital CCTV operators. Early evidence from one of the first facial recognition CCTV systems in the world, the 'Facit' system at Newham in East London, certainly suggests that first generations of the technology, at least, rarely identify stipulated individuals effectively in open street situations (Meek, 2002). However, since this system was installed, major technological progress has ensued, although, as of 2003 'the ability to match a face in a crowd [was] still elusive' (Norris, 2003: 271).

2 'A biology of culpability': embedding prejudice into code?

Importantly, the potential for effective recognition also varies heavily between different social or ethnic groups. An analysis by Lucas Introna of various trials of facial recognition CCTV systems concludes, for example, that 'for the top systems ... identification rates for males were 6% to 9% points higher than for females ... Recognition rates for older people were higher than for younger people' (2003: 20). Moreover, Introna quotes the official report evaluating the trial which confirms that 'Asians are easier [to recognize] than whites, African-Americans are easier than whites, [and] other race members are easier than whites' (FRVT, 2002: 8). Incorporated into complex, ongoing software-sorting CCTV systems, the potential for such discrepancies to be translated into major geographical and social inequalities is clearly immense.

Three prime concerns arise here. First, there is the question of the invisibility of operation and design of such systems. Introna and Wood (2004) argue that the apparently mundane design decisions that go into facial recognition CCTV systems, and the code embedded in them, need to be opened up to scrutiny. They argue that the 'silent', passive and utterly invisible code within facial recognition CCTV systems – where even the location of the software-sorting process may be far from the gaze of the cameras – must be made visible if the configurations and implications of such software-sorting processes are to be exposed. This is a prerequisite, they argue, if any hope can be sustained that such systems can be brought under any form of democratic scrutiny and regulation (Introna and Wood, 2004: 195). The great fear, Introna and Wood argue, is that the racial, social or gender biases reported among operators of manual CCTV systems (see Norris and Armstrong, 1999), may be directly translated into the very facial recognition algorithms that are the basis for the software-sorting process.

Secondly, Mitchell Gray (2003) argues that facial recognition CCTV systems decontextualize the behaviour of human subjects from their observation or detection. They remove the contingency of discretion and local knowledge that once characterized the way human law enforcement personnel decided whether to use sanctions of force (Koskela, 2003; Norris, 2003). And they threaten to open the door to a widening universe of algorithmically policed systems which detect the supposed biometric or digital signifiers of social or individual pathology at a more or less considerable distance, as defined by a highly dubious set of 'scientific' subdisciplines who have much to gain from the ubiquitous application of these technologies. Nikolas Rose (2000), referring to the emerging biocriminology which links code, surveillance, and genetic or biometric detection, calls this an emerging 'biology of culpability'. Here Gray (2003: 325) notes that micro-expression detectors are already being developed within the US military to detect 'unusual expressions' not supposedly associated with their location of behaviour.

Finally, there are grave dangers that algorithmically controlled CCTV systems might work to deepen already establish ecologies of normalization, and demonization, within neoliberal urban landscapes of power. Exaggerating logics of exclusion against 'failed consumers', the young, refugees/asylum seekers, or other demonized minorities, within the increasingly polarized landscapes of many contemporary cities, these very logics could, conceivably, be embedded in biases within the very code that makes facial recognition CCTV systems work (see Reeve, 1996). Indeed, it is conceivable that such biometric and individualized systems could destroy the anonymized interactions that have long been central characteristics of city spaces. A new ontology of the body could be ushered in which uses software-sorting techniques to continuously police and stipulate notions of the purported value, fitness, riskiness, worth and legality of subjects, based on the continuous scanning of a whole suite of biometric signatures, as people move within and between city spaces (van der Ploeg, 1999).

To Phil Agre (2001), such a shift could usher in a 'tremendous change in our society's conception of the human person. People would find strangers addressing them by name' in previously anonymized encounters in city streets and commercial spaces. More worrying still, normalized, commercial judgements, based on continuous connections to credit registers and the like, could connect very closely processes of consumer marginalization to this new logic of personalized monitoring (Agre, 2001).

VI Conclusions: towards a spatial politics of code

This paper has sought to underline the centrality of software-sorting in structuring contemporary social and geographical inequalities. It has also attempted to illustrate the need to maintain a broad, multisectoral perspective which can capture how different software-sorting techniques are encroaching across different dimensions of contemporary societies. Given the limited space available here, I would like to finish by briefly underlining four central questions raised by this discussion.

First, it is very clear from this discussion that software-sorting must be at the centre of any attempt to conceptualize the formation, maintenance and experience of social and geographical inequalities within contemporary capitalist societies. A pressing imperative for human geography, in particular, is to fully address, and excavate, the power of code and software-sorting techniques in continually orchestrating the geographies of contemporary inequality. Software-sorting techniques are diffusing rapidly to mediate the production, consumption and experience of physical and electronic mobility systems and spaces, urban neighbourhoods, a whole plethora of service, finance, and communication systems, and even city streets. So powerful and invisible have such domains of technosocial power become that geographers and other social scientists addressing social inequality will surely face nothing short of a paradigm crisis of irrelevance if they do not address them with much more sophistication, energy and urgency than they have done hitherto. As Amin and Thrift suggest, software-sorting techniques, and computerized code more generally, 'are becoming one of the chief ways of animating the city. They must not be allowed to take us unaware' (Amin and Thrift, 2002: 128).

It is therefore time for a concerted, multidisciplinary effort to try and open up the 'black boxes' that trap software-sorting, and the cultural and spatial politics of code, within their esoteric, largely unknown, and almost completely opaque, technocratic worlds (Eischen, 2003). For, crucially, software-sorting practices 'must become transparent if we are to evaluate critically the politics of mobility'. as well as those of inequality, citizenship, the city, and the body, more generally (Aday, 2004a: 1377).

This paper has begun to demonstrate how, through the application of software-sorting techniques, whole swathes of the social and public realms of cities, and the essential private and pubic service domains of advanced industrial nations, are rapidly being 'mass customized', unbundled, commodified, individualized, and coordinated through networked technologies linking scales from the globe to the body. Very often, this is being accomplished based on combinations of neoliberal, consumeristic principles and ideologies of governance, new technological assemblages, and intensifying surveillance capabilities. In post-Keynesian, neoliberal contexts, it is clear that software-sorting techniques provide critical political sites. This is especially so as, currently, they are being overwhelmingly implemented to address perceived imperatives among service providers of offering favoured groups and places enhanced services, rights and mobilities, and improved real or perceived security, while, very often, working directly to undermine the prospects of marginalized groups and communities.

Secondly, while the vague contours of software-sorted geographies outlined here are, indeed, now starting to become apparent, a whole range of vitally important research questions remain virtually unaddressed. In what ways, for example, do the inequalities that are constantly and automatically produced through software-sorting map onto the more familiar geographies and spatialities of inequality within and between contemporary cities? How do multiple systems of software-sorting interact and combine together? Do their redistributive effects multiply through positive feedback loops to favour and disfavour broadly the same individuals, groups and places? Do such compound effects reinforce broader trends that have been identified towards the 'splintering' of the sociotechnical and geographical fabric of contemporary cities (Graham and Marvin, 2001)? If so, might this herald the onset, as Lieven de Cauter (2004) has termed it, of a sort of 'capsular civilization' dominated by the cultures and biopolitics of (attempted) separation, a vast infrastructure of continuous, digital filtering and tracking, and the cultural politics of fear? Or do these effects work in more complex and contradictory ways, as they interact with the more subtly biased practices that, I would argue, have tended to mark the service cultures of Keynesian and electromechanical service regimes?

A second group of key research questions surrounds the subjectivities of service use and mobility within software-sorted domains. How, for example, do such techniques influence the identities, experiences, affect and perceptions of those on the receiving end of software-sorting? Does the varying level of (in)visibility among such techniques – for example between relatively invisible electronic mobility systems and relatively visible city street and physical transport systems – affect such subjectivities and experiences?

A final group of research questions emerges when we consider the linkages between the widespread implementation of software-sorting systems and the extending spatial divisions of labour and mobility within neoliberal capitalism more broadly. What, for example, are the geographies of production, diffusion and operation of the vast universe of software-sorting systems and techniques now being implemented? How are they enmeshed within broader transnational divisions of labour within information and data processing industries and how are their 'front' and 'back-office' elements, linking the points of data capture to the moments of algorithmic judgement, geographically structured? How do software-sorted systems influence the broader geographies of mobility and development, as their embedded algorithms mediate larger and larger parts of the transnational geographies of production, distribution and consumption? What are the broader political geographies of production, consumption, regulation and governance of software-sorted service domains? Finally, how are the social and normative judgements, and inclusions, that form the heart of these systems altered and adapted as they diffuse between different geographical, social and sectoral sites and contexts?

Our third critical conclusion concerns the practicalities and epistemologies of social research on software-sorting. How, for example, can social and geographical research aimed at excavating the social and spatial politics of code, and the impacts of software-sorting techniques on the production and experience of inequalities, best progress? Given the opaque, fast-moving and deeply arcane nature of this crucial new realm of produced inequalities, how can social and geographical research hope to genuinely address this challenge? Given the inevitably confidential, proprietary and highly technical nature of the core algorithms that now socially sort so many key social domains, what research techniques and paradigms can offer any genuine assistance here? Clearly, the research challenges here are considerable. This is especially so given that, from the point of view of social geographic research, the worlds of software-sorting tend not to be amenable in any meaningful way to traditional geographical or social scientific research techniques and conceptualizations (Thrift and French, 2002).

This paper's fourth conclusion raises the critical question of appropriate political responses to the spatial politics of software-sorting. How can regulation, policy and resistance address the rapid and multiscaled diffusion of automated software-sorting techniques across contemporary societies? When such techniques tend to rely on their true opacity, invisibility, and topological configuration to elude any real attempts at public regulation from polities which are necessarily jurisdictionally embedded, how can states and policy-makers begin to respond? In what ways can policy-makers, in the diverse reams now affected, truly gain knowledge of, and leverage over, the software-sorting techniques that are embedded at the heart of the emerging inequalities? What policy instruments might best address these fast-moving domains, bringing standards, transparency, and democratic oversight where at present there exists a universe of unfettered, 'frontier' technoscience? Can such policy makers avoid the ever-deepening encroachment of software-sorted techniques, and the resulting emergence of societies where a universe of electronic code continually works to imprint neoliberal and consumerist logics – with virtual invisibility – onto a growing proportion of social and economic exchanges? Finally, what scope is there for creative resistance through which social movements, activists, and participatory technological spaces can work to infiltrate and expose the inequities that are being digitally encoded into such routine, but essential, transactions?

This latter point exposes an especially promising area of geographical action and policy research. For the inherent flexibility of software-sorting techniques opens up important normative questions as to how they can be shaped progressively to sustain empowering innovations and restructurings in service regimes, rather than the more usual and often highly inequitable processes of consumerization, splintering and commodification that have been the main concern of this paper. Participatory, online GIS systems offer an interesting example here. The Neighborhood Knowledge Los Angeles (NKLA) initiative, for example, has successfully exposed the geographic data sets used to systematically red-line deteriorating neighbourhoods in LA – a major boost to social movements working to publicly regulate these processes (see http://nkla.ucla.edu/). Another good example of the progressive potential of software-sorting involves the construction of household surveillance systems which 'learn' about the habits and routines of elderly or disabled people living in their homes, use algorithms to judge when these have been significantly departed from, and then automatically alert emergency services.[2] Finally, software-sorting techniques could be invaluable in re-engineering road transport systems, based on environmental sustainability principles, so that heavy polluters were forced to pay relatively high amounts for their use of the road system on a pay-per-distance basis (Foley *et al*., 2003).

In addressing this wide research, policy and activist agenda, the challenge is to maintain a critical and informed position without falling foul of dystopian and absolutist scenarios suggesting that software-sorting techniques are somehow limitless, completely integrated, and all-powerful. As Koskella (2003) suggests, 'urban space will always remain less knowable and, thus, less controllable than the restricted panoptic space'. Spaces which escape the reach of regressive software-sorting systems do and will remain. A politics of transgressing, resisting, and even dismantling such increasingly inequitable systems is possible. Software-sorting techniques also offer much potential for progressive and empowering policy innovations. And, crucially, as Ash Amin and Nigel Thrift put it, the:

> networks of control that snake their way through cities are necessarily oligoptic, not panoptic: they do not fit together. They will produce various spaces and times, but they cannot fill out the whole space of the city – in part because they cannot reach everywhere, in part because they therefore cannot know all spaces and times, and in part because many new spaces and times remain to be invented. (Amin and Thrift, 2002: 128)

Acknowledgements

The author would like to gratefully acknowledge the support of British Academy

Research Readership award (2003–2005), without which this research would not have been possible. Thanks also to the three anonymous referees for their useful comments. Finally, thanks to Chris Dunn, Sue Smith, David Lyon, Peter Aday and Clive Norris for comments on an earlier draft. The usual disclaimers apply.

Notes

1. These are, first, the concept of 'joint-supply' (or nonrivalness) meaning that, if a service, such as the national defence or legal system, is supplied to one person, it can also be supplied to all other persons at relatively little extra cost. The second concept – 'nonexcludability' – means that, once a supply has been built, a user cannot be prevented from consuming the service (e.g., traditional city streets). Thirdly, there is 'nonrejectability'. This means that, once a service is supplied, it must be equally consumed by all, even those who do not wish to consume it (e.g., public street cleaning) (Pinch, 1985).
2. See http://marc.med.virginia.edu/library_techrev.html (last accessed February 2005).

References

Aday, P. 2004a: Surveillance at the airport: Surveilling mobility/mobilising surveillance, *Environment and Planning A* 26, 1365–80.

— 2004b: Secured and sorted mobilities: examples from the airport. *Surveillance and Society* 1, 500–19.

Agre, P. 2001: Your face is not a bar code: arguments against automatic face recognition in public places. *Whole Earth* 106, 74–77.

Amin, A. and **Thrift, N.** 2002: Cities: *reimagining the urban* Cambridge: Polity.

Andrejevic, M. 2003: Monitored mobility in the era of mass customization. *Space and Culture* 6, 132–50.

Avaya Corporation 2000: *Avaya CRM solutions: individual service management*. Washington, DC: Avaya Inc.

Bloomfield, B. 2001: In the right place at the right time: electronic tagging and the problems of social order/disorder. *Sociological Review* 49, 174–218.

Bolter, J. and **Grusin, R.** 2000: *Remediation: understanding new media*. Cambridge, MA: MIT Press.

Bowker, G. and **Leigh-Star, S.** 1999: *Sorting things out*. Cambridge, MA: MIT Press.

Brenner, N. 2004: *New state spaces: urban governance and the rescaling of statehood*. Oxford: Oxford University Press.

Burrows, R. and **Ellison, N.** 2004: Sorting places out? Towards a social politics of neighbourhood informatization. *Information, Communication and Society* 7, 321–26.

Burrows, R. and **Gane, N.** 2004: Geodemographics, software and class. Unpublished paper (available from the authors at rjb7@york.ac.uk).

Callon, M. 1986: Some elements of a sociology of translation: domestication of the scallops and the fisherman of St Brieuc Bay. In Law J., editor, *Power, action and belief: a new sociology of knowledge* London: Routledge, 196–232.

Castells, M. 1996: *The rise of the networked society*. Oxford: Blackwell.

Cisco (2002): *Service provider quality of service – design guide*. Washington, DC: Cisco Inc.

Cresswell, T. 2001: The production of mobilities. *New Formations* 43, 11–25.

Cuff, D. 2002: Immanent domain: pervasive computing and the public realm. *Journal of Architectural Education* 57, 43–49.

Curry, D. 1998: *Digital places: living with geographic information technologies*, London: Routledge.

de Cauter, L. 2004: *The capsular civilization: on the city in the age of fear*. Rotterdam: NAI publishers.

Dodge, M. and **Kitchin, R.** 2004: Flying through code/space: the real virtuality of air travel. *Environment and Planning A* 36, 195–211.

— 2005: Codes of life: identification codes and the machine-readable world. *Environment and Planning D: Society and Space* 22, in press.

Eischen, K. 2003: Opening the 'black box' of software. *Information, Communication and Society* 6, 57–81.

Facial Recognition Vendor Test (FRVT) 2002: Retrieved 15 November 2004 from www.frvt.org

Foley, J. and **Fergusson, M.** 2003: *Putting the brakes on climate change*. London: Institute for Public Policy Research.

Garland, D. 2001: *The culture of control*. Oxford: Oxford University Press.

Goss, J. 1995: 'We know who you are and we know where you live': the instrumental rationality of geodemographic systems. *Economic Geography* 71, 171–98.

Graham, S. 1998: Spaces of surveillant-simulation: new technologies, digital representations, and material geographies. *Environment and Planning D: Society and Space* 16, 483–504.

— 2002: CCTV: the stealthy emergence of a Fifth Utility. *Planning Theory and Practice* 3, 237–41.

— 2004a: Introduction: from dreams of transcendence to the 'remediation' of urban space. In Graham, S., editors, *The cybercities reader* London: Routledge, 1–29.

— 2004b: The software-sorted city: rethinking the 'digital divide'. In Graham, S., editors, *The cybercities reader*, London: Routledge, 324–32.

— 2004c: Beyond the 'dazzling light': from dreams of transcendence to the 'remediation' of urban life. *New Media and Society* 6, 33–42.

Graham, S. and **Marvin, S.** 2001: *Splintering urbanism: networked infrastructures, technological mobilities and the urban condition*. London: Routledge.

Graham, S. and **Wood, D.** 2003: Digitising surveillance: categorisation, space and inequality. *Critical Social Policy* 23, 227–48.

Gray, M. 2003: Urban surveillance and panopticism: will we recognize the facial recognition society? *Surveillance and Society* 1, 314–33.

Haggerty, K. and **Ericson, R.** 2000: The surveillant assemblage. *British Journal of Sociology* 51, 605–22.

Haythornthwaite, C. and **Wellman, B.** 2002: Moving the Internet out of cyberspace. In Wellman, B. and Haythornthwaite, C., editors, *The Internet and everyday life*, Oxford: Blackwell, 3–44.

Holmes, D. 2000: The electronic superhighway: Melbourne's CityLink project. *Urban Policy and Research* 18, 32–45.

Hook, P. 2001: Police systems to automatically detect crime. *CCTV Today* March, 19–20.

Hunter, J. 2002: World without secrets: *business, crime and privacy in the age of ubiquitous computing*. London: Wiley.

Introna, L. 2003: The politics of the digital face: facial recognition systems in 'smart' CCTV. Unpublished paper (available from the author).

Introna, L. and **Nissenbaum, H.** 2000: Shaping the web: why the politics of search engines matter. *The Information Society* 16, 169–85.

Introna, L. and **Wood, D.** 2004: Picturing algorithmic surveillance: the politics of facial recognition systems. *Surveillance and Society* 2, 177–98.

Jones, R. 2001: Digital rule: punishment, control and technology. *Punishment and Society* 2, 5–22.

Koskela, H. 2003: 'Cam era' – the contemporary urban panopticon. *Surveillance and Society* 1, 292–313.

Latour, B. and **Hermand, E.** 1998: *Paris ville invisible*. Paris: La Decouverte.

Leigh-Star, S. 1999: The ethnography of infrastructure. *American Behavioral Scientist* 43, 377–91.

Lessig, L. 1999: *Code and other laws of cyberspace*. New York: Basic Books.

Lianos, M. 2003: Social control after Foucault. *Surveillance and Society* 1, 412–30.

Lianos, M. and **Douglas, M.** 2000: Dangerization and the end of deviance. *British Journal of Criminology* 40, 261–78.

Luke, R. 2002: Habit@online: web portals as purchasing ideology. *Topia* 8, 112–34.

Lyon, D. 2003a: *Surveillance as social sorting: privacy, risk and digital discrimination*. New York: Routledge.

— 2003b: Surveillance as social sorting: computer codes and mobile bodies. In Lyon, D., editors, *Surveillance as social sorting: privacy, risk and digital discrimination*, New York: Routledge, 13–30.

— 2004: Technology vs. 'terrorism': circuits of city surveillance since September 11, 2001. In Graham, S., editor, *Cities, war and terrorism*, Oxford: Blackwell, 297–311.

Meek, J. 2002: Robo cop. *Guardian* 2, 13 June, 2–4.

Meyer, M. 2001: Delivering the future: e-freight. Retrieved 16 September 2004 from www.intermodal.org/FIRE/meyerpaper.hyml

Norris, C. 2003: From personal to digital: CCTV, the panopticon, and the technological mediation of suspicion and social control. In Lyon, D., editor, *Surveillance as social sorting: privacy, risk and digital discrimination*, New York: Routledge, 249–81.

Norris, C. and **Armstrong, G.** 1999: *The maximum surveillance society: the rise of CCTV*. Oxford: Berg.

Phillips, D. and **Curry, M.** 2003: Privacy and the phenetic urge: geodemographics and the changing spatiality of local practice. In Lyon, D. editor, *Surveillance as social sorting: privacy, risk and digital discrimination*, New York: Routledge, 137–52.

Pickles, J., editor 1995: *Ground truth: the social implication of geographic information systems*. New York: Guildford.

Pinch, S. 1985: *Cities and services: the geography of collective consumption*. London: Routledge.

Reeve, A. 1996: The private realm of the managed town centre. *Urban Design International* 1, 61–80.

Rifkin, N. 2001: *The age of access: the new culture of hypercapitalism where all of life is a paid-for experience*, New York: Penguin.

Rose, N. 2000: The biology of culpability: pathological identity and crime control in a biological culture. *Theoretical Criminology* 4, 5–34.

Sheller, M. 2004: Mobile publics: beyond the network perspective. *Environment and Planning D: Society and Space* 22, 39–52.

Sheller, M. and **Urry, J.** 2000: The city and the car. *International Journal of Urban and Regional Research* 24, 737–57.

Thrift, N. 2004a: Movement-space: the changing domain of thinking resulting from the development of new kinds of spatial awareness. *Economy and Society* 33, 582–604.

— 2004b: Remembering the technological unconscious by foregrounding knowledges of position. *Environment and Planning D: Society and Space* 22, 175–90.

— 2004c: *Driving* in the city. *Theory, Culture and Society* 21, 41–59.

Thrift, N. and **French, S.** 2002: The automatic production of space. *Transactions of the Institute of British Geographers* NS 27, 309–35.

Urry, J. 2000: *Sociology beyond societies: mobilities for the twenty-first century*. London: Routledge.

van der Ploeg, I. 1999: The illegal body: 'Eurodac' and the politics of biometric identification, *Ethics and Information Technology* 1, 295–302.

Winseck, D. 2003: Netscapes of power: convergence, network design, walled gardens, and other strategies of control in the information age. In Lyon, D., editor, *Surveillance as social sorting: privacy, risk and digital discrimination*, London: Routledge, 176–98.

Woolgar, S., editor 2002: *Virtual society? Get real!* Oxford: Oxford University Press.

Young, J. 1999: *The exclusive society*. London: Sage.

Zureik, E. 2004: Governance, security and technology: the case of biometrics. *Studies in Political Economy* 73, 113–37.