

Principles of Spatial Analysis

WEEK 07: GEODEMOGRAPHICS



This week

- Geodemographic classifications
- k-means clustering

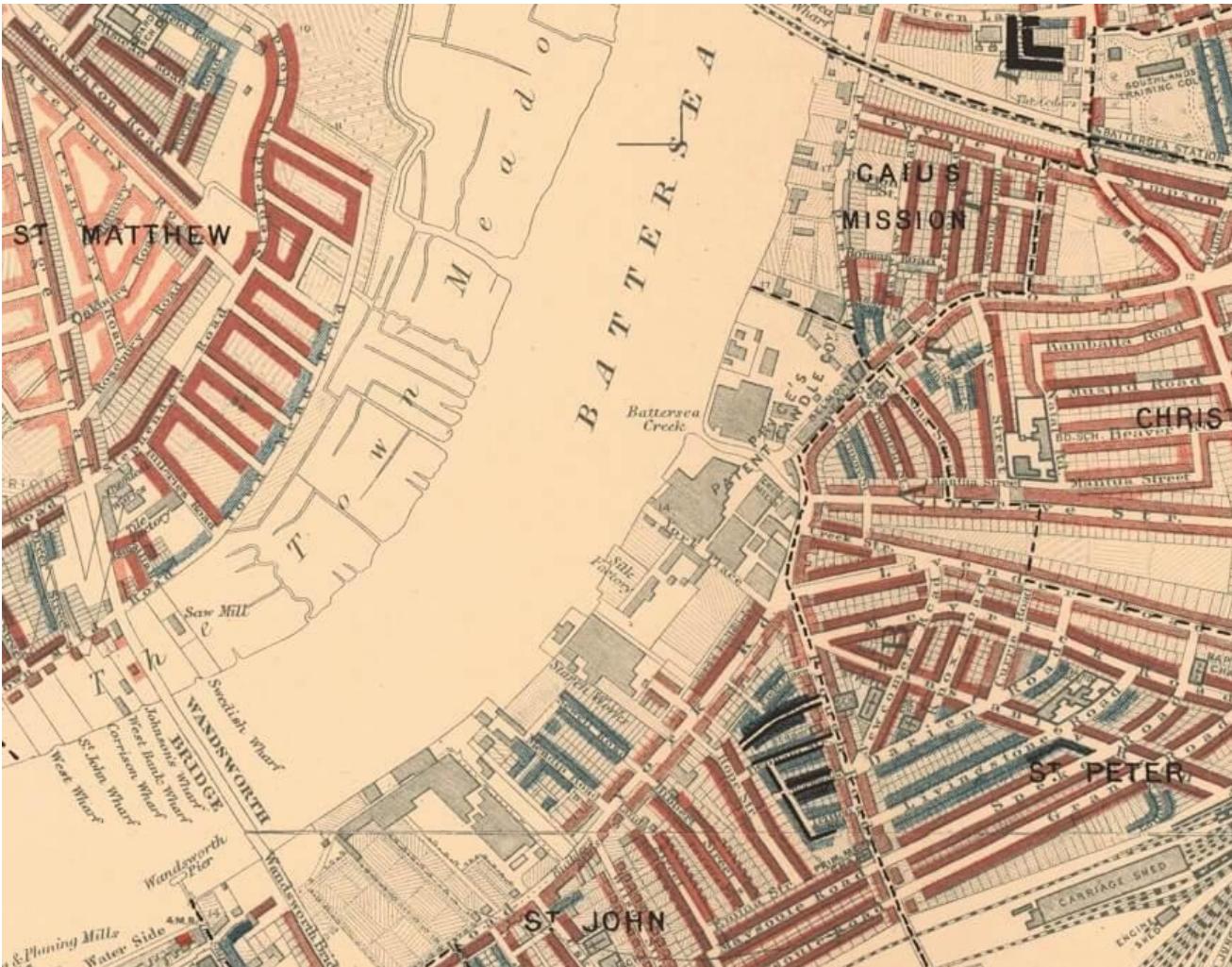
Geodemographics

- Analysis of people (*demographics*) by where they live (*geo*).
- Used to identify similar neighbourhoods or administrative areas.
- Means of multivariate data reduction for the differentiation of areas.
- Been around for many many years, arguably dating back to the late 1800s.

Charles Booth

- Created the first geodemographic-style classification.
- Shipping business owner and philanthropist.
- Survey: *Life and Labour of People in London*.
- He noticed that there is a geographical pattern in the distribution of different social categories: people who live in a particular neighbourhood and share similar living conditions, are of similar characteristics and social status.

Charles Booth



Maps Descriptive of London Poverty 1889. Charles Booth's *Inquiry into Life and Labour in London* (1886-1903).

Charles Booth

Classification	Colour	
Lowest class. Vicious, semi-criminal.	Black	
Very poor, casual. Chronic want.	Dark blue	
Poor. 18s. to 21s. a week for a moderate family.	Light blue	
Mixed. Some comfortable others poor.	Purple	
Fairly comfortable. Good ordinary earnings.	Pink	
Middle class. Well-to-do.	Red	
Upper-middle and upper classes. Wealthy.	Yellow	

Geodemographics

- Further developed in 1970s to target urban deprivation funding.
- Commercial sector also got involved (CACI: ACORN / Experian: MOSAIC).
- Office for National Statistics' Output Area Classification (2001, 2011, 2021).
- ONS' Output Area Classification completely open using Census data.

Geodemographics

Singleton *et al.* 2020:

"A geodemographic classification is created by assembling a wide range of measures that describe the characteristics of areas and/or those people living within them, and then, through the implementation of unsupervised learning (clustering), identifies groups of areas that share common characteristics. Emerging clusters may be divided or aggregated to create a hierarchy, and it is typical that these be accompanied by labels, descriptions, photographs, diagrams and graphs."

Variable selection

Choice of measures can create bespoke classifications:

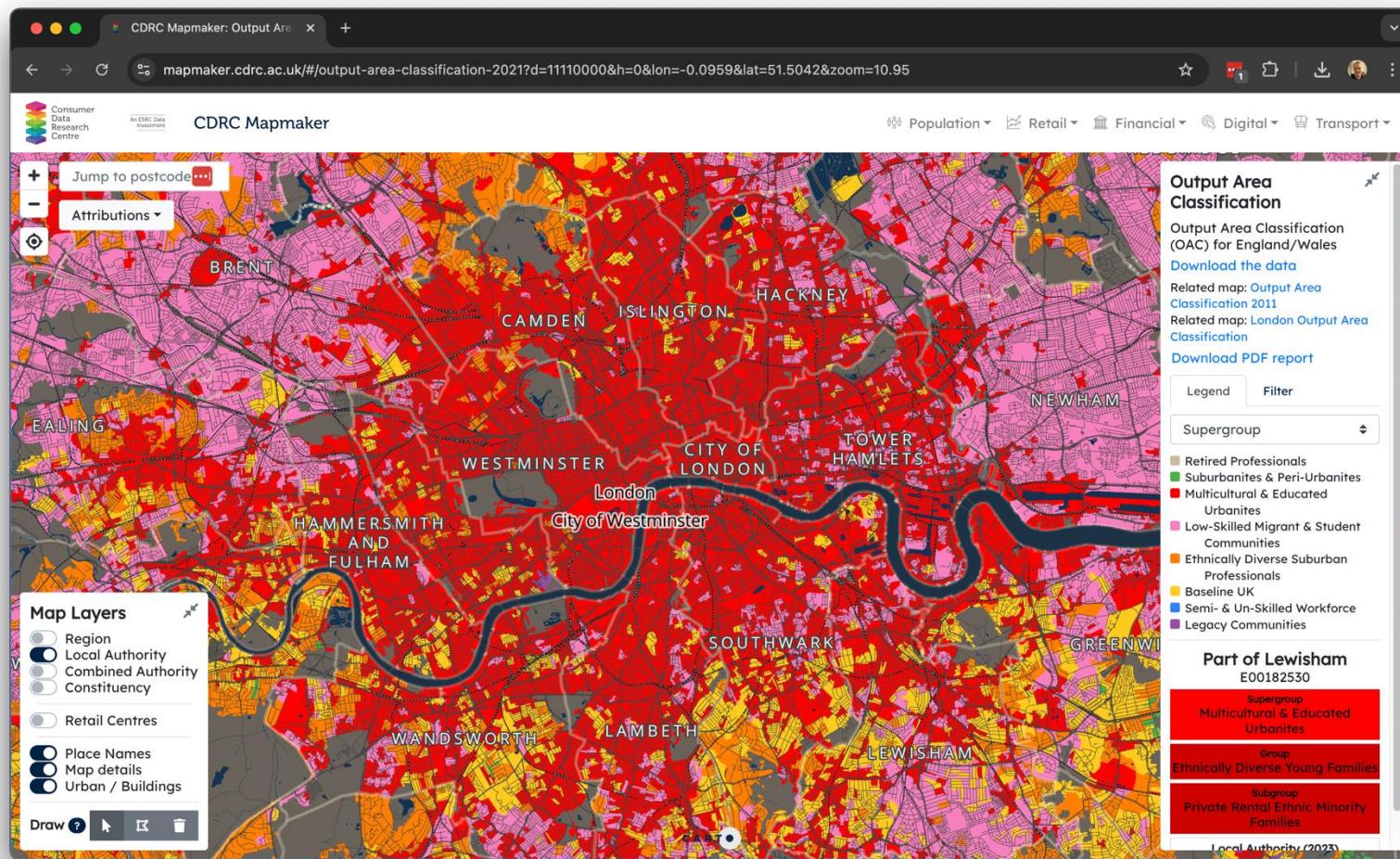
- Output Area Classification: ~60 census variables, focused on holistic understanding of area characteristics.
- Workplace Zones Classification: 48 census variables across 4 domains, focused on workers and workplaces.
- Internet User Classification: built from a range of consumer, survey and open (census) data focusing on how populations interact with the internet (use and engagement).

Clustering

Variables are **partitioned** into clusters using the k-means clustering algorithm and then mapped to their respective areal unit, e.g. Output Area, Workplace Zone:

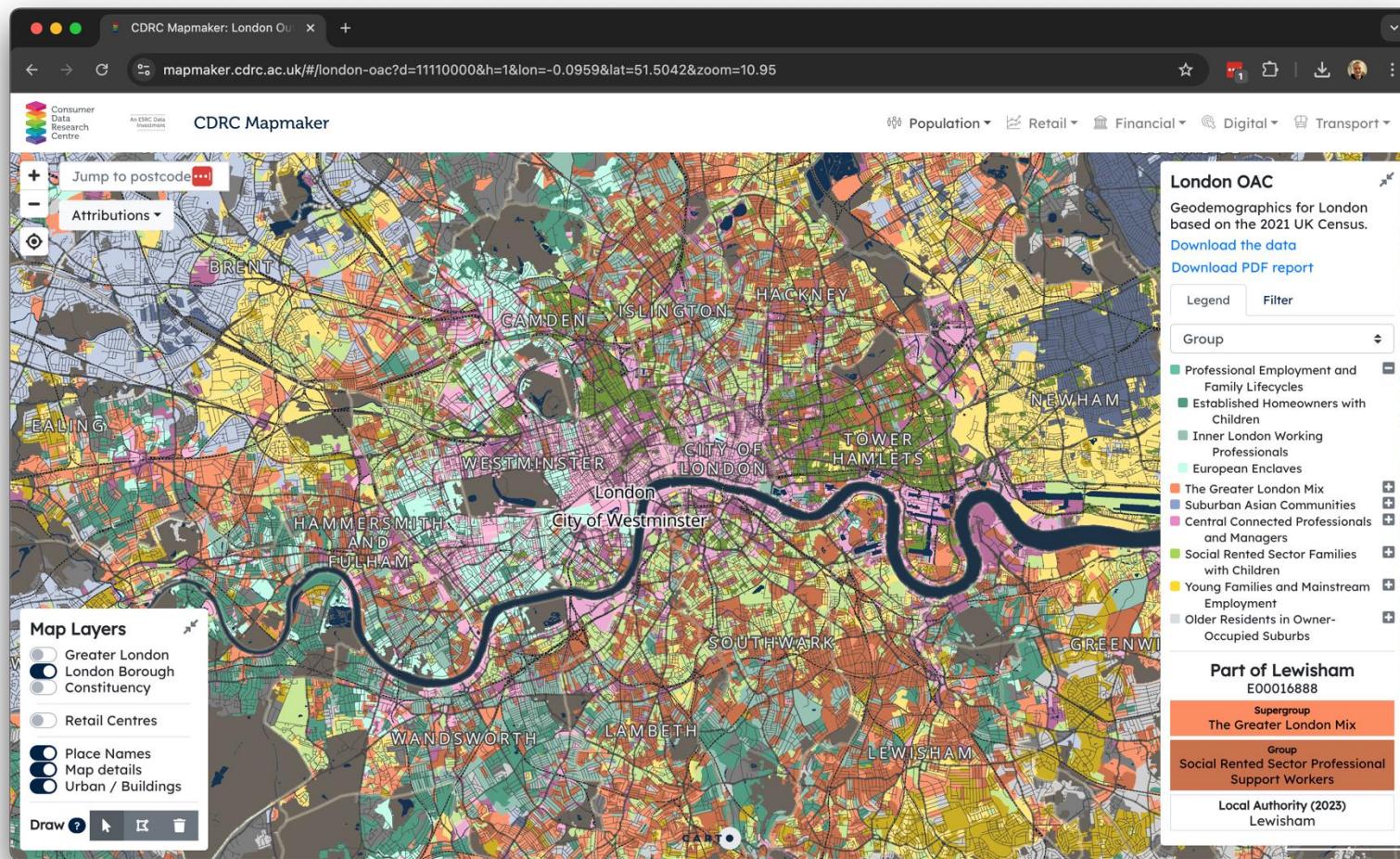
- Sometimes there is a hierarchy of clusters (e.g. supergroups, clustergroups).
- Each cluster will have a name and description (pen portrait).

Geodemographics



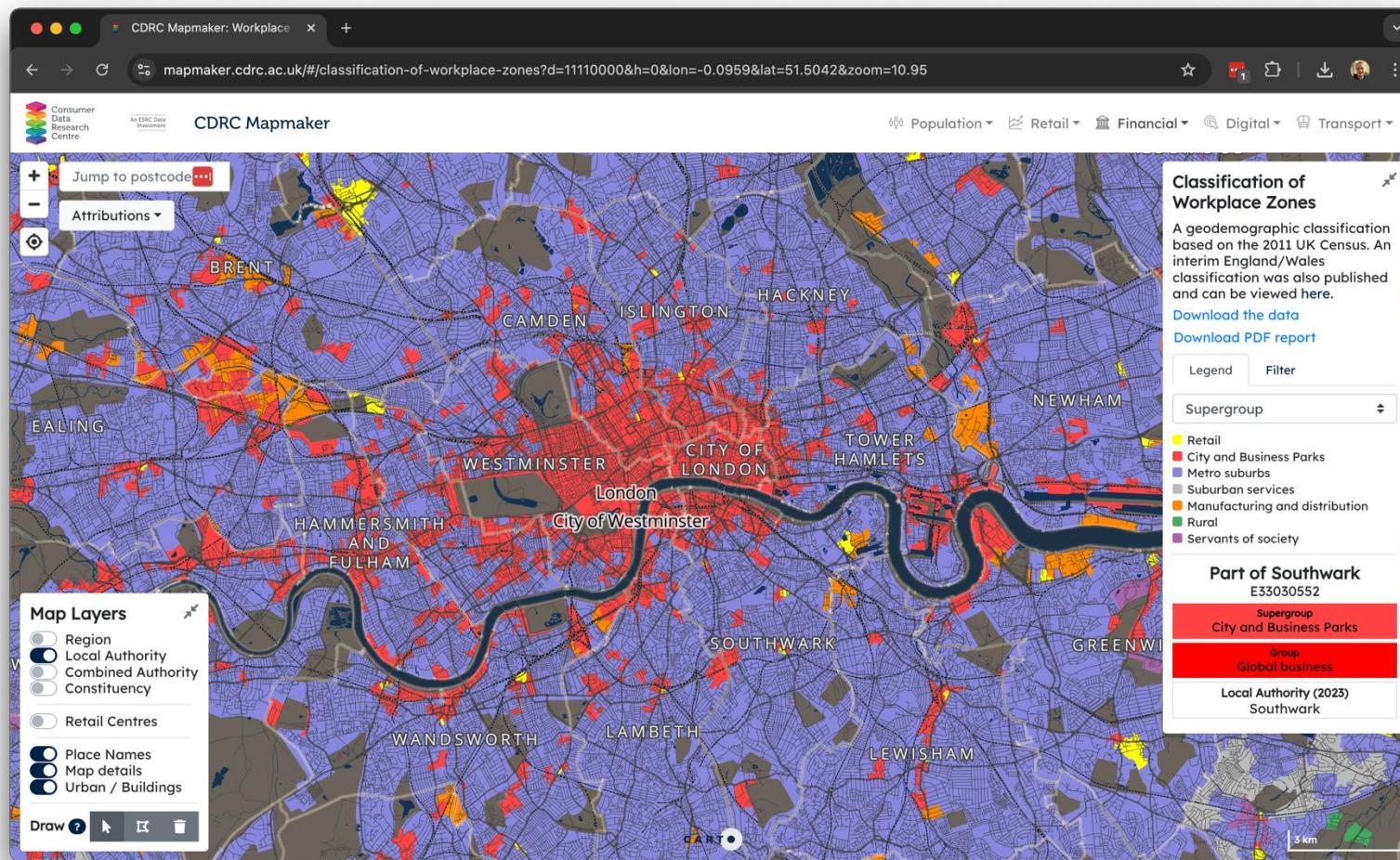
2011 Output Area Classification on mapmaker.cdrc.ac.uk

Geodemographics



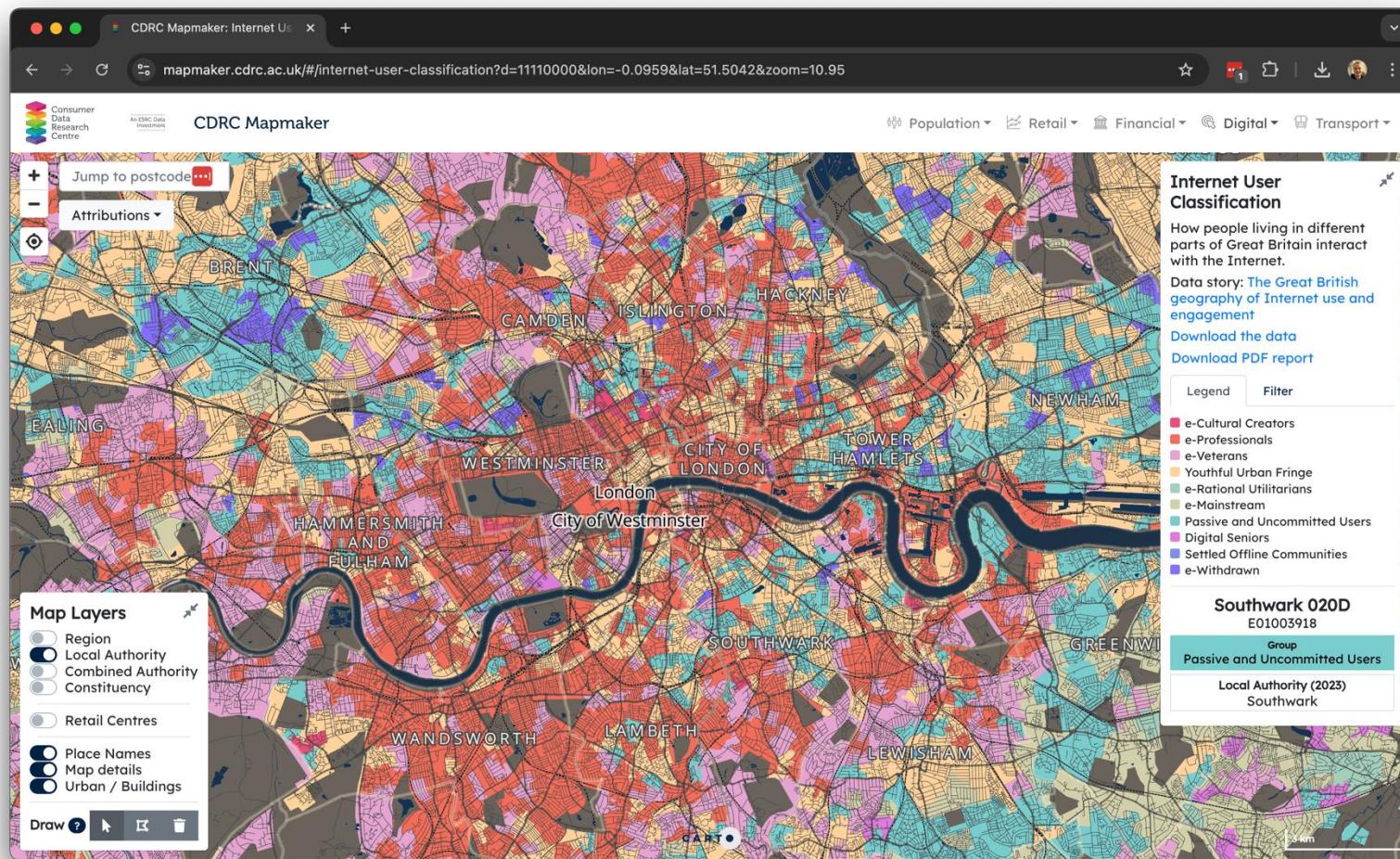
2021 London Output Area Classification on mapmaker.cdrc.ac.uk

Geodemographics



Workplace Zone Classification on mapmaker.cdrc.ac.uk

Geodemographics



Internet User Classification on mapmaker.cdrc.ac.uk

Limitations

- Highly dependent on the input data.
- Input data can get old very quickly (depending on the topic).
- Inherent biases within the input data – see also the optional article by Dalton and Thatcher (2015) on reading list.

Applications

Using the geodemographic classification as input for further analysis:

- Harris *et al.* 2007: differences in school choice between social groups
- Brundson *et al.* 2011: participation in higher education
- Martin *et al.* 2018: analysis of travel-to-work flows
- Goodman *et al.* 2011: socio-economic inequalities in exposure to air pollution
- Trasberg and Cheshire 2021: profiling changing activity patterns

Internet user classification

Singleton *et al.* 2020:

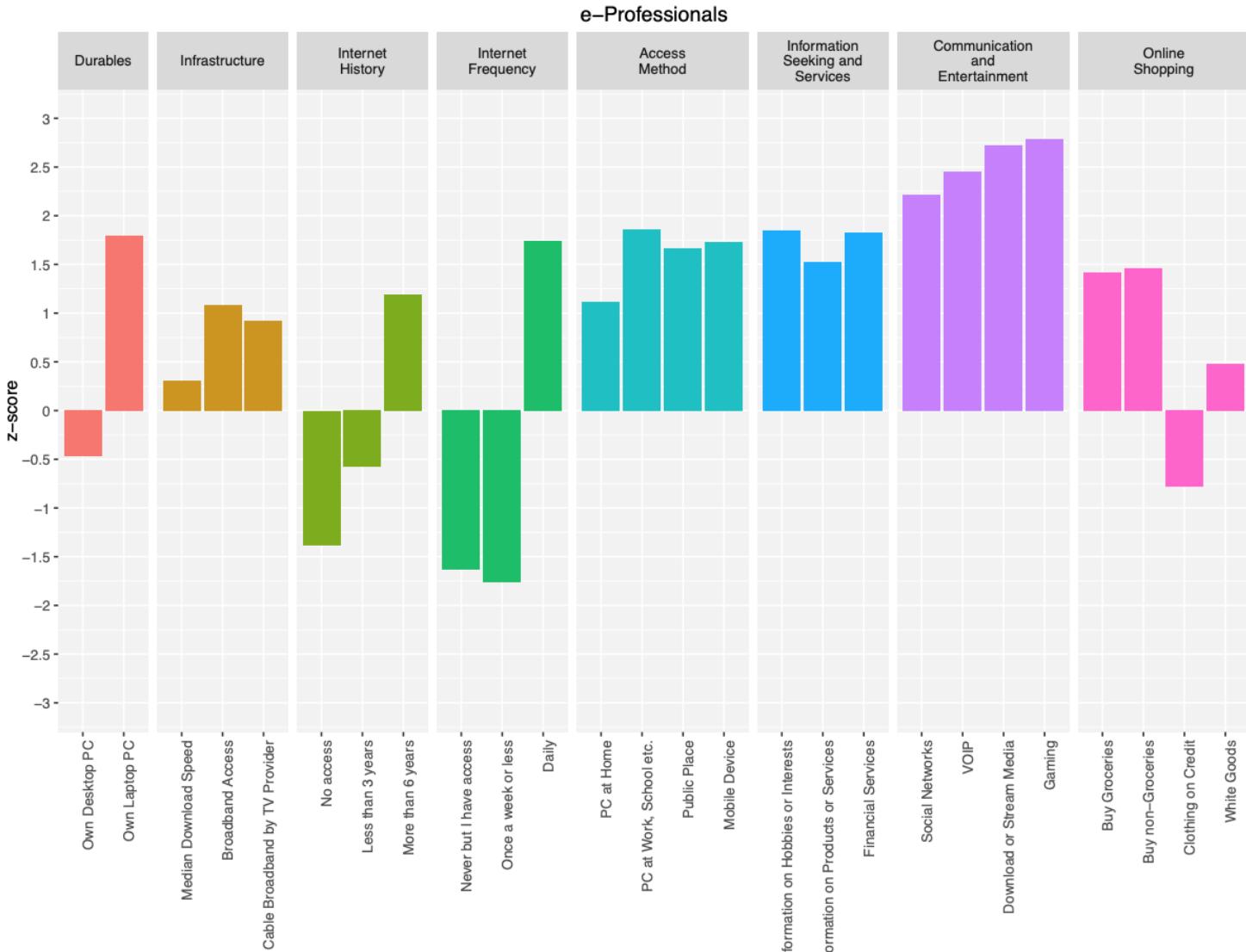
- Bespoke classification created by CDRC researchers.
- 'Profiles of internet use and engagement'.
- Built from a range of consumer data, survey data, and open data.

Internet user classification

Several noteworthy variables:

- British Population Survey: internet access, frequency of internet usage, access to PC, type of internet use.
- Transactional (consumer) data on online shopping.
- Average broadband speed.
- Census variables such as age, ethnicity.
- National Statistics Socio-economic classification (NS-SEC)

Internet user classification



Internet User Classification mean attributes of the *e-Professionals*

Internet user classification

e-Professionals:

"This Group has high levels of Internet engagement, particularly regarding social networks, communication, streaming and gaming, but relatively low levels of online shopping, besides groceries. They are new but very active users, with a very high proportion of the population engaging on a daily basis. (...) Geographically, this Group is mainly located close to the city centre or within the proximity of Higher Education Institutes, where infrastructure accessibility, such as cable broadband, is sufficient."

Internet user classification

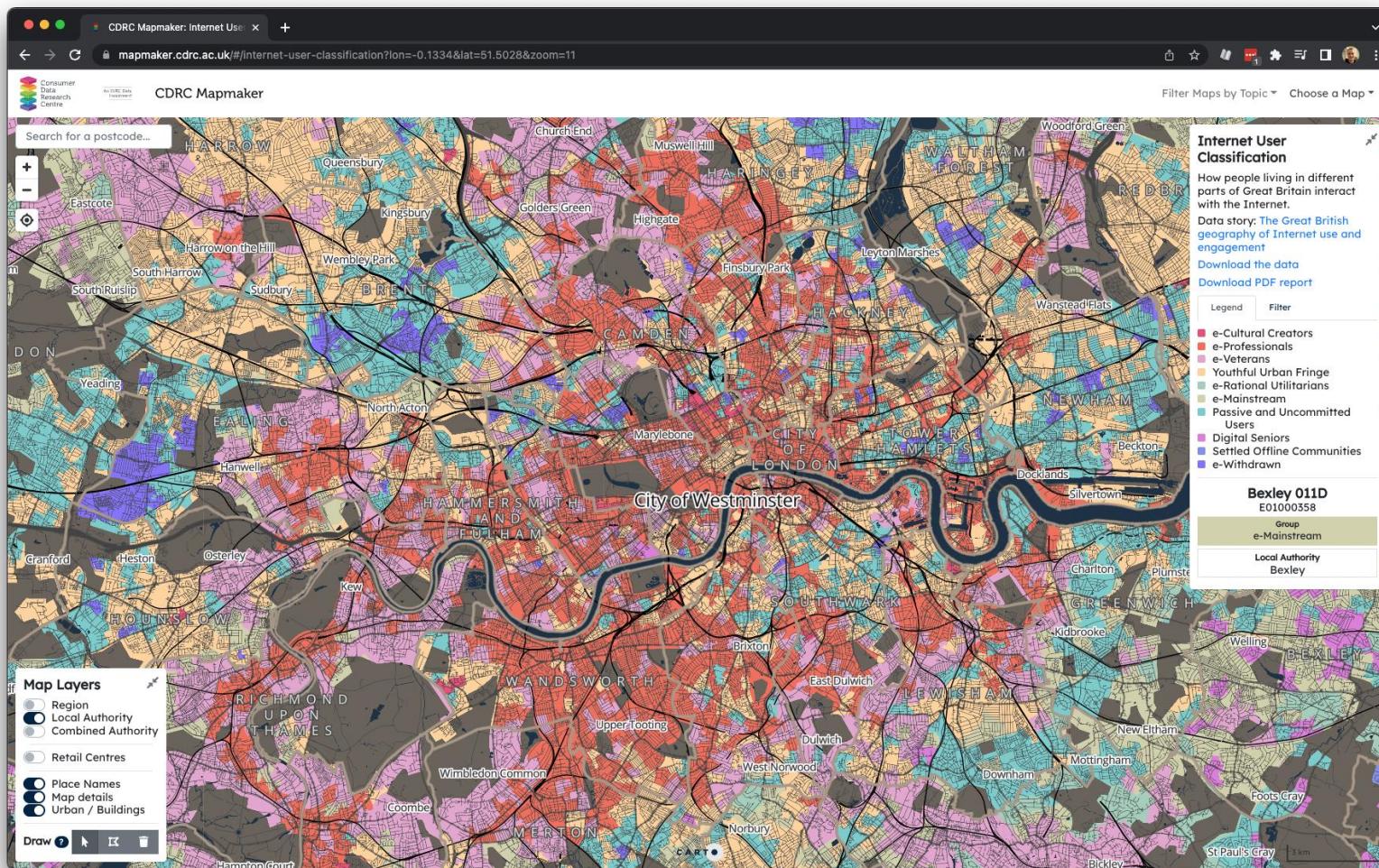
- Measures of access to and use of internet.
- Identification of areas to target potential interventions.
- Analysis of areas where people are likely to work from home.

Workflow

msoa_iuc_input.csv

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W		
1	msoa1cd	age_total	age0to4pc	age5to14pc	age16to24pc	age25to44pc	age45to64pc	age65pluspc	nssec_total	1_higher_mi	2_lower_mi	ma_3_intermedi_4_employers_5_lowerr_supt_7_routine	8_unemploy	avg_dwn_sp	avb_superfa	no_decent_b	bband_speed	bba	bband_sp	bba	bba	bba	bba		
2	E02000001	7375	0.032	0.38779966	0.09613595	0.40691525	0.27254237	0.06074576	5816	0.38462861	0.33906465	0.07806052	0.06464924	0.02596286	0.04041651	0.02665062	0.03696699	24.4	0.544	0.002	0.013	0.249	0.2		
3	E02000002	6775	0.09269373	0.12162362	0.11321033	0.2801478	0.18568266	0.09800738	3926	0.05680082	0.17116658	0.14314824	0.1162048	0.06444218	0.20529801	0.13015792	0.11436577	77.7	0.988	0.01	0.02	0.159	0.2		
4	E02000003	10045	0.08292683	0.10154306	0.11796914	0.3060229	0.248888	0.06460926	6483	0.08175228	0.20761993	0.18247725	0.11059695	0.07064631	0.15502082	0.09656023	0.09532624	74.3	0.99	0.002	0.008	0.164	0.2		
5	E02000004	6182	0.05904238	0.10239405	0.13879004	0.2544848	0.2495956	0.08864445	4041	0.067805	0.20638456	0.19079436	0.10541945	0.08364266	0.15070527	0.12150458	0.07374412	81.1	0.992	0.008	0.026	0.162	0.2		
6	E02000005	8562	0.09296893	0.11936463	0.11948143	0.21361831	0.1949621	0.05361052	5386	0.04936662	0.16635619	0.15648286	0.10413563	0.0873696	0.14456036	0.0992921	0.070.7	0.97	0.03	0.021	0.223	0.2			
7	E02000007	8791	0.10340121	0.12535548	0.12854055	0.28460926	0.19747469	0.06882038	5158	0.05641722	0.16265995	0.13609926	0.09402869	0.07968205	0.18321055	0.15645599	0.13144663	75.3	0.988	0.012	0.006	0.177	0.2		
8	E02000008	11569	0.10216959	0.1159132	0.11893854	0.2995073	0.20779127	0.06232172	7152	0.04194631	0.15464204	0.10025168	0.07969799	0.18945749	0.15450224	0.12108501	0.27.9	0.995	0.005	0.004	0.153	0.2			
9	E02000009	8395	0.09731988	0.10720667	0.13126861	0.32126262	0.20762359	0.04597975	5279	0.05190377	0.16859254	0.13638947	0.11252131	0.07861337	0.1397867	0.13316196	0.12502368	68.9	1	0	0.008	0.189	0.2		
10	E02000010	8615	0.10562972	0.12222867	0.12153221	0.3045098	0.20290192	0.05200232	5243	0.04051024	0.16784284	0.14724394	0.10432958	0.08048827	0.18539004	0.14896052	0.12073241	73.5	0.999	0	0.002	0.039	0.2		
11	E02000011	6187	0.08323909	0.10085644	0.12978827	0.26830451	0.24159895	0.06911731	3904	0.05060931	0.18545082	0.17622951	0.12295082	0.08330541	0.16137295	0.12909836	0.08529713	75.5	0.995	0.001	0.007	0.113	0.2		
12	E02000012	9888	0.0785801	0.11043689	0.14178803	0.29277913	0.21399676	0.06260113	6056	0.09048877	0.20756275	0.16363937	0.12863737	0.05977543	0.13996592	0.08768164	0.12285337	76.8	0.999	0	0.004	0.132	0.2		
13	E02000013	8402	0.10580814	0.12678455	0.14096095	0.2978505	0.20233278	0.05236848	5044	0.04361618	0.15992027	0.15087232	0.10229976	0.083636376	0.18933386	0.15622522	0.11399683	73.6	1	0	0.008	0.201	0.2		
14	E02000014	9402	0.09817070	0.12093172	0.11929593	0.29259732	0.21697511	0.05626463	5826	0.04170958	0.14933059	0.13594233	0.09972537	0.08324751	0.19910745	0.17061449	0.12032369	73.5	1	0	0.003	0.04	0.2		
15	E02000015	7563	0.10273970	0.11556261	0.1159132	0.11893854	0.2995073	0.06232172	4637	0.04393700	0.15464284	0.13419384	0.09747432	0.08104161	0.18977787	0.15203796	0.143843	64.3	0.999	0.001	0.002	0.115	0.2		
16	E02000016	7676	0.12441374	0.10682647	0.14369463	0.44046379	0.11737884	0.01055237	4563	0.09883848	0.15904742	0.1003725	0.10190664	0.06421214	0.15318866	0.10870042	0.17773395	53.4	0.939	0	0.003	0.044	0.2		
17	E02000017	8498	0.08602024	0.09837609	0.14179807	0.36060614	0.05409579	5309	0.08537505	0.18698517	0.12325669	0.1191044	0.06162835	0.15567282	0.10591783	0.1624576	74.5	1	0	0.002	0.045	0.2			
18	E02000018	8890	0.11158605	0.12463442	0.12609674	0.31169854	0.1904387	0.04623137	5356	0.04686333	0.15832711	0.13629574	0.10306199	0.09055265	0.19062733	0.14395071	0.13032114	71.5	0.999	0	0.014	0.192	0.2		
19	E02000019	8276	0.10681489	0.11829386	0.1161189	0.3221363	0.19864669	0.04809087	5029	0.05050706	0.17458739	0.14714655	0.10161066	0.07595944	0.18373434	0.15887851	0.10757606	73.3	0.964	0.013	0.011	0.161	0.2		
20	E02000020	9276	0.10155239	0.11858566	0.11664511	0.32823733	0.18510314	0.05868158	5473	0.05838428	0.17397399	0.13630513	0.10508094	0.07457478	0.16718436	0.13447835	0.14598964	77.7	0.995	0.005	0.008	0.126	0.2		
21	E02000021	7904	0.10235324	0.11652328	0.11955972	0.29617915	0.21862348	0.05452935	4783	0.04787799	0.17854938	0.1436337	0.11394522	0.08028434	0.18293958	0.13798871	0.11478152	72.5	0.994	0.004	0.005	0.145	0.2		
22	E02000022	8777	0.14230375	0.1444685	0.11222513	0.31401049	0.1914094	0.04881070	4888	0.05277153	0.14915132	0.11392923	0.09899775	0.06443035	0.16040173	0.14747392	0.21640417	61.5	0.993	0.002	0.002	0.044	0.2		
23	E02000023	6482	0.1349899	0.13159591	0.12419007	0.34464671	0.15869602	0.0336316	3666	0.04825518	0.15372627	0.1300436	0.09514722	0.07524537	0.19056707	0.13849509	0.16848919	68.8	0.997	0.003	0.012	0.16	0.2		
24	E02000024	10156	0.06213070	0.09462387	0.0950172	0.28406853	0.08881449	5695	0.1950975	0.26309571	0.28406853	0.17375268	0.07767231	0.04533234	0.12845407	0.04480956	0.07677231	0.04152353	0.04436146	46.7	0.96	0.024	0.013	0.233	0.2
25	E02000025	7956	0.06460533	0.08157366	0.10232172	0.31271998	0.26181898	0.07352261	5457	0.16657504	0.292656164	0.15063222	0.11379879	0.04892798	0.10298699	0.06303833	0.16138904	50.7	0.982	0.001	0.003	0.061	0.2		
26	E02000026	6313	0.06621258	0.0963092	0.09662601	0.27546333	0.2689688	0.07381594	4174	0.17537135	0.27407762	0.17073402	0.14542405	0.04120748	0.0807379	0.05630091	0.05654049	42.8	0.995	0.002	0.005	0.153	0.2		
27	E02000027	9598	0.07075694	0.09203103	0.10507757	0.30595973	0.24424072	0.07110954	5636	0.1566714	0.28424415	0.14389638	0.1407263	0.04843861	0.16046817	0.05624556	0.0651171	57.8	0.999	0	0.004	0.142	0.2		
28	E02000028	6166	0.06779111	0.08968589	0.1037905	0.30181641	0.25089199	0.07525138	4153	0.18468577	0.29568896	0.15843966	0.12352516	0.04520769	0.08427463	0.05201046	0.05633481	48.3	0.942	0	0.004	0.075	0.2		
29	E02000029	8517	0.12831396	0.10261829	0.10226606	0.3117725	0.24914876	0.05577081	5681	0.14205246	0.27583172	0.1612922	0.12480197	0.051394	0.11218215	0.06688963	0.06565746	37.3	0.97	0	0.007	0.162	0.2		
30	E02000030	9130	0.05125958	0.10799562	0.10624315	0.21971523	0.2886562	0.05419496	5865	0.18952831	0.28354646	0.13554987	0.15260017	0.03614663	0.09224211	0.05234442	0.05831202	45.2	0.912	0.004	0.026	0.185	0.2		
31	E02000031	7294	0.06471072	0.08815465	0.09542089	0.28900464	0.24143131	0.1076227	4691	0.20677894	0.2929013	0.14218717	0.12928307	0.0370923	0.08271158	0.04732466	0.06118099	56.1	0.953	0.017	0.005	0.14	0.2		
32	E02000032	7857	0.05905562	0.10271096	0.10602011	0.25378643	0.27771414	0.07012855	5144	0.1714619	0.27527216	0.15746501	0.15824261	0.04179627	0.08786936	0.05520995	0.05268274	57	0.982	0	0.009	0.17	0.2		
33	E02000033	8537	0.06852524	0.10097224	0.1049549	0.31116132	0.24469954	0.06758815	5620	0.11921708	0.24786477	0.16423488	0.13950178	0.05498221	0.11014235	0.07295374	0.0911032	49.9	0.998	0	0.006	0.156	0.2		
34	E02000034	8508	0.07075694	0.09203103	0.10507757	0.30595973	0.24424072	0.07110954	5636	0.1566714	0.28424415	0.14389638	0.1407263	0.04843861	0.16046817	0.05624556	0.0651171	57.8	0.999	0	0.004	0.142	0.2		
35	E02000035	7965	0.06804771	0.07407407	0.08612681	0.3578154	0.21933459	0.08851224	5344	0.20303144	0.2877994	0.13117515	0.11957335	0.03967066	0.09281437	0.04977545	0.07616018	62.4	0.913	0	0.003	0.059	0.2		
36																									

Workflow



Workflow

Typical workflow:

1. Choose input domains.
2. Select associated quantifiable variables.
3. Measure variables for multi-collinearity.
4. Transform and standardise variables.
5. Choose a clustering method.
6. Determine the number of clusters.
7. Interpret, test, and finalise findings.

Input domain

- What type of application is your classification aimed at?
- Who or what are you segmenting? Individuals, households, postcodes, output areas, wards?
- What is the scale of data available?
- What difficulties might arise from combining datasets?

Variables

- Partially subjective: no single or unique set of variables.
- Balancing act of theory, available data and statistical considerations.
- Selection of variables directly impact what is classified.

Multi-collinearity

- The correlation coefficient (or r-squared value) ranges from -1 to 1.
- A value closer to 1 or -1 indicates a stronger association between the two variables.
- Variables with correlation coefficients greater than ± 0.8 are considered highly correlated.
- You may choose to replace or retain a variable based on a compelling rationale.

Standardise variables

Normalise to control for non-uniformity of areal units:

- Expressing variables as percentages or proportions (e.g. using a relevant population denominator).

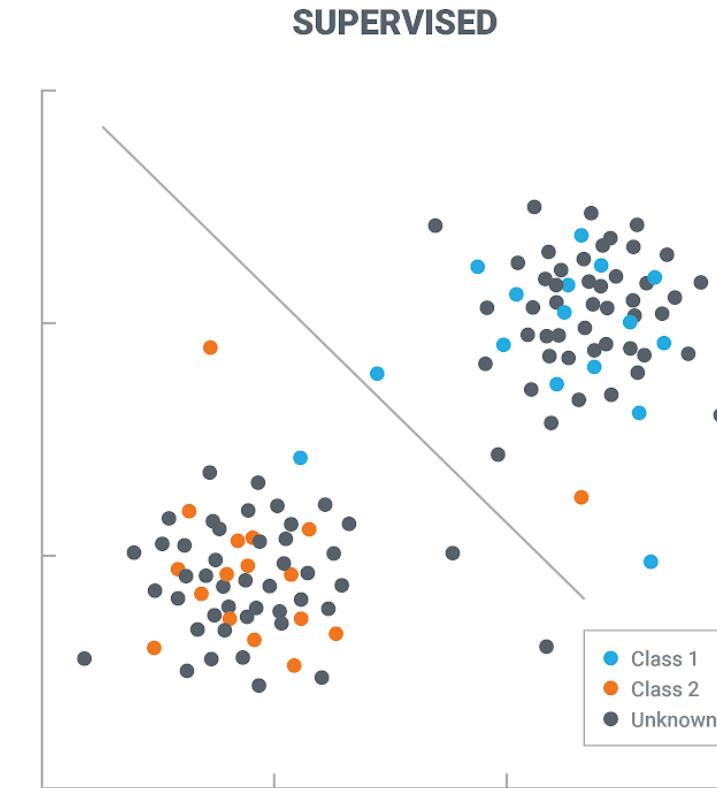
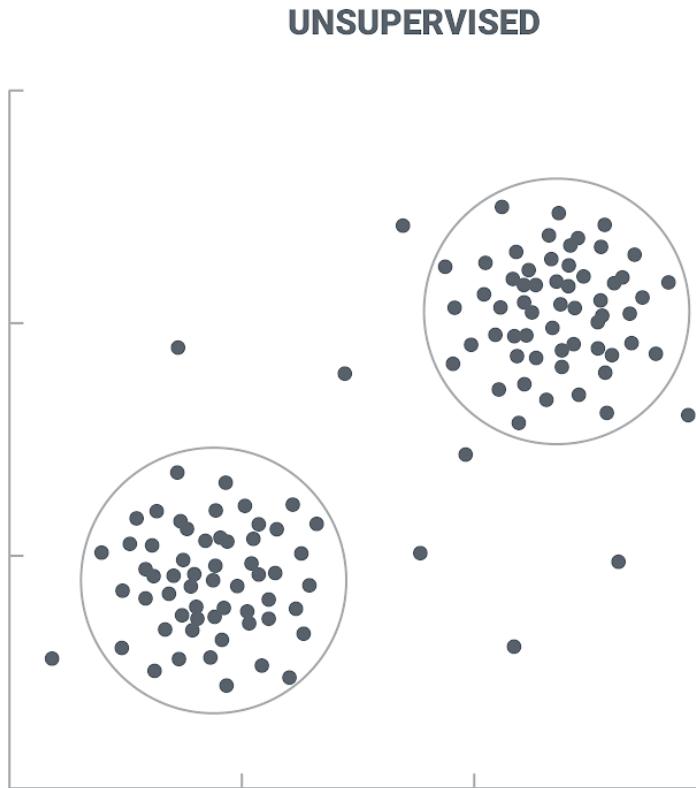
Standardise between variables to account for value ranges:

- Transform all variables to be on the same scale.
- z-scores, range standardisation.

Clustering

- Different methods often create different groups.
- Selecting the best outcome and optimal number of clusters often relies on user intuition and judgment.
- The process can be computationally intensive, depending on the size of the input data.
- The methods employed are unsupervised, meaning they rely on patterns in the data without prior labels.

Unsupervised versus supervised



k-means

- Assign geographic areas with common underlying attributes to similar classification groups.
- k clusters (pre-defined) of n individual observations.
- Each observation can have any number of attribute data.
- Used in: Internet User Classification, ONS 2011 Output Area Classification, ONS 2021 Output Ara Classification.

k-means



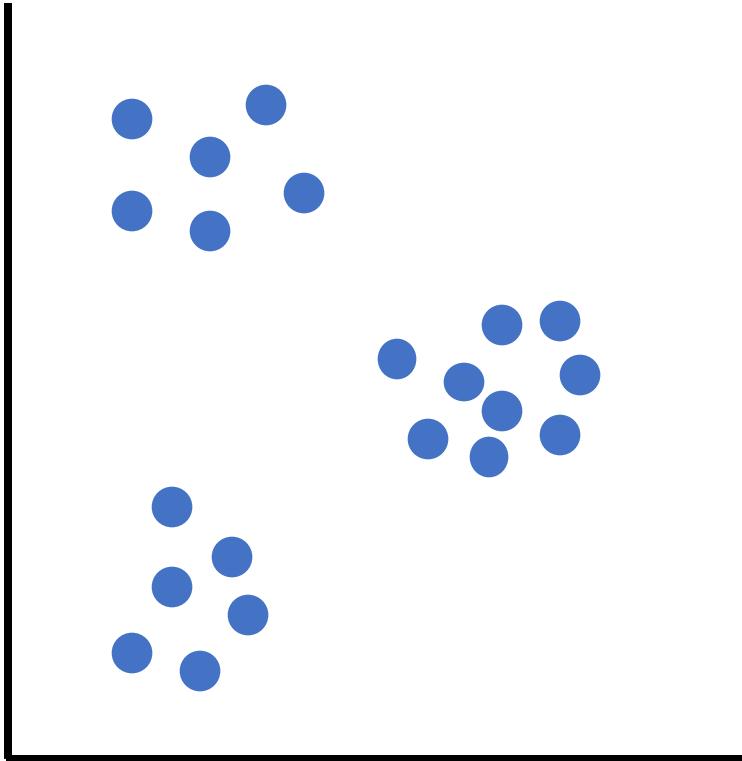
k-means

- Minimising the distance between an observation's input variables to the means of the respective cluster groups.
- Maximising the distance between cluster groups.
- Number of clusters defined a priori.

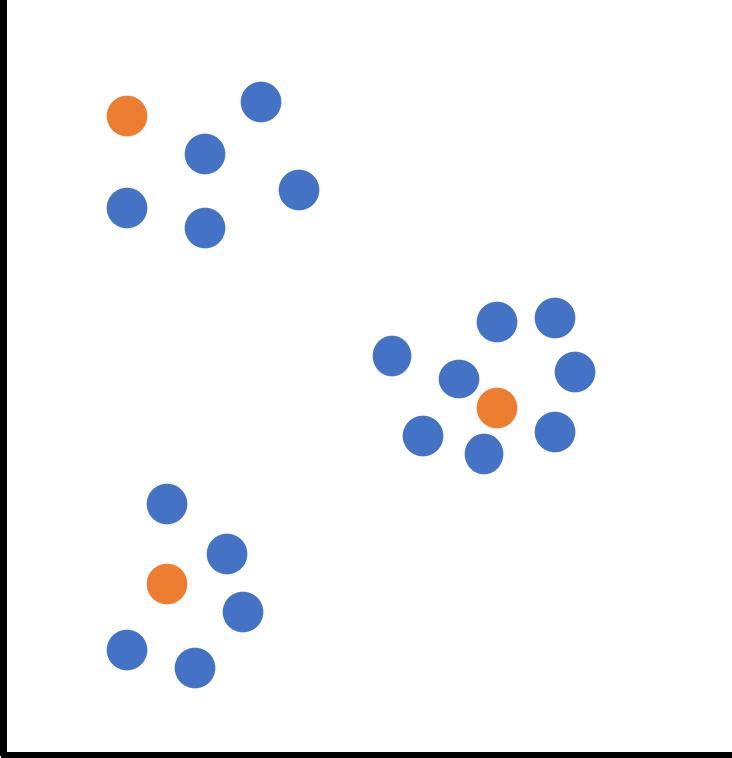
Process

- Step 1: identify your k
- Step 2: randomly identify k distinct data points as initial cluster centre
- Step 3: assign each observations to the nearest cluster
- Step 4: calculate the mean of each cluster
- Step 5: repeat with mean value becoming new cluster centre until no change

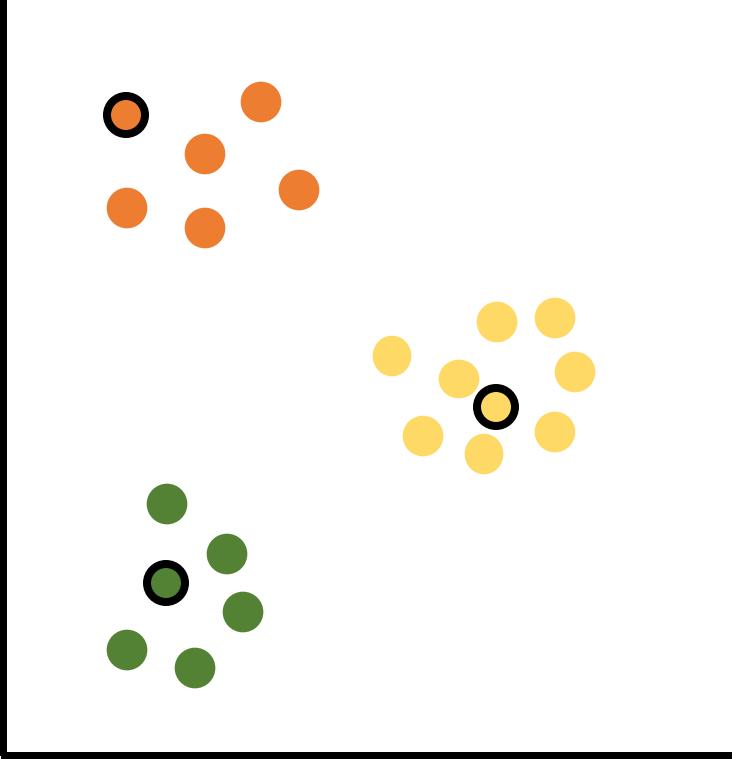
Step 1



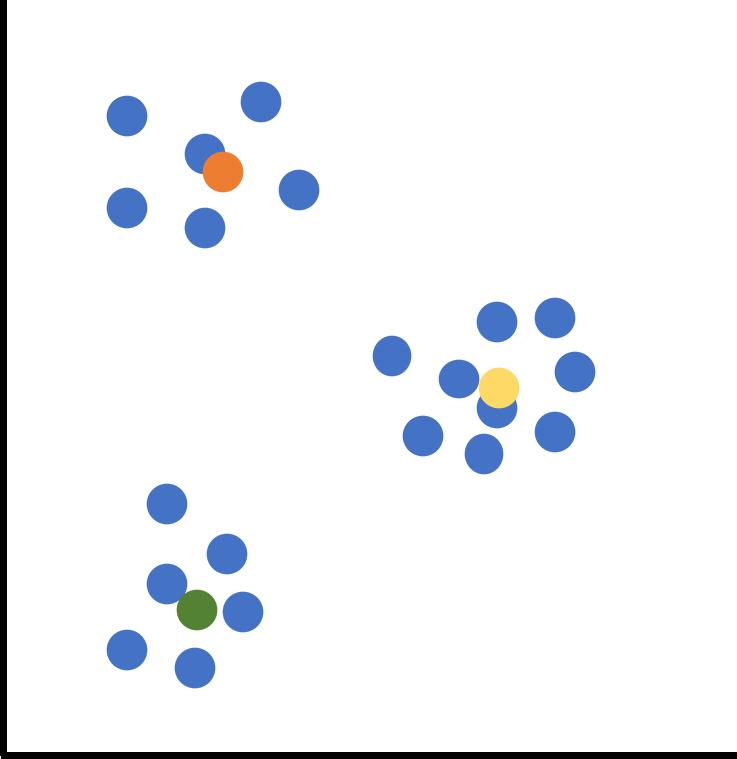
Step 2



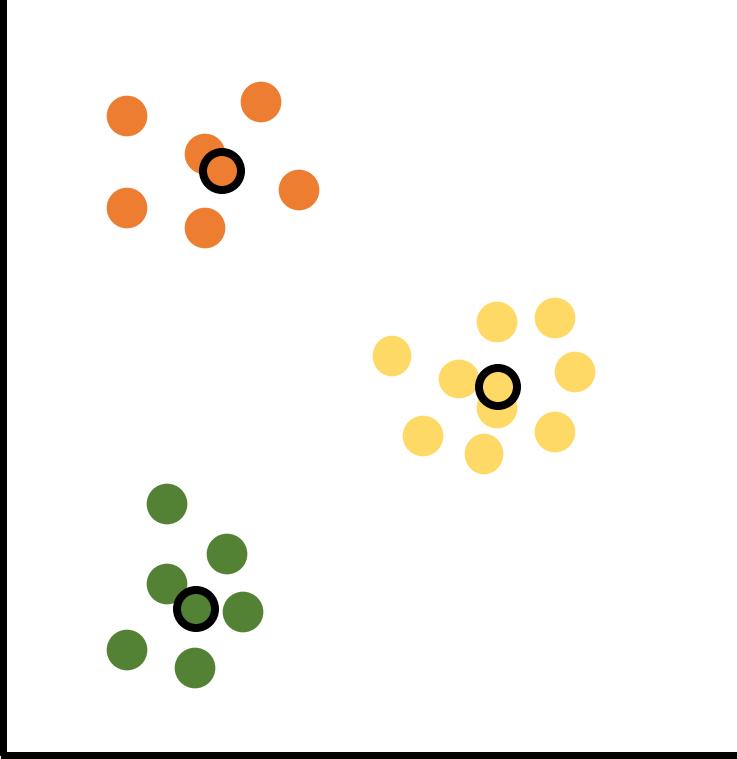
Step 3



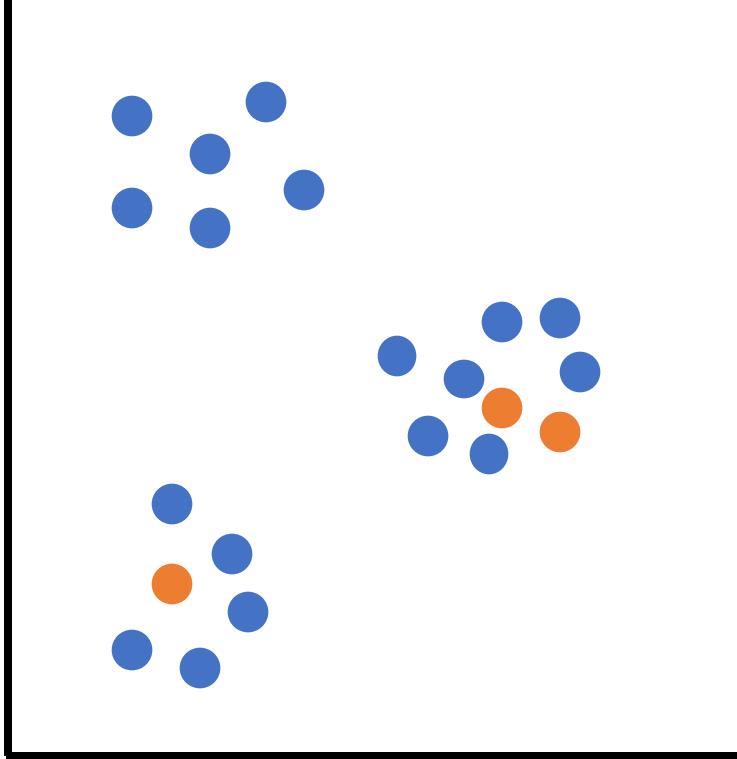
Step 4



Step 5



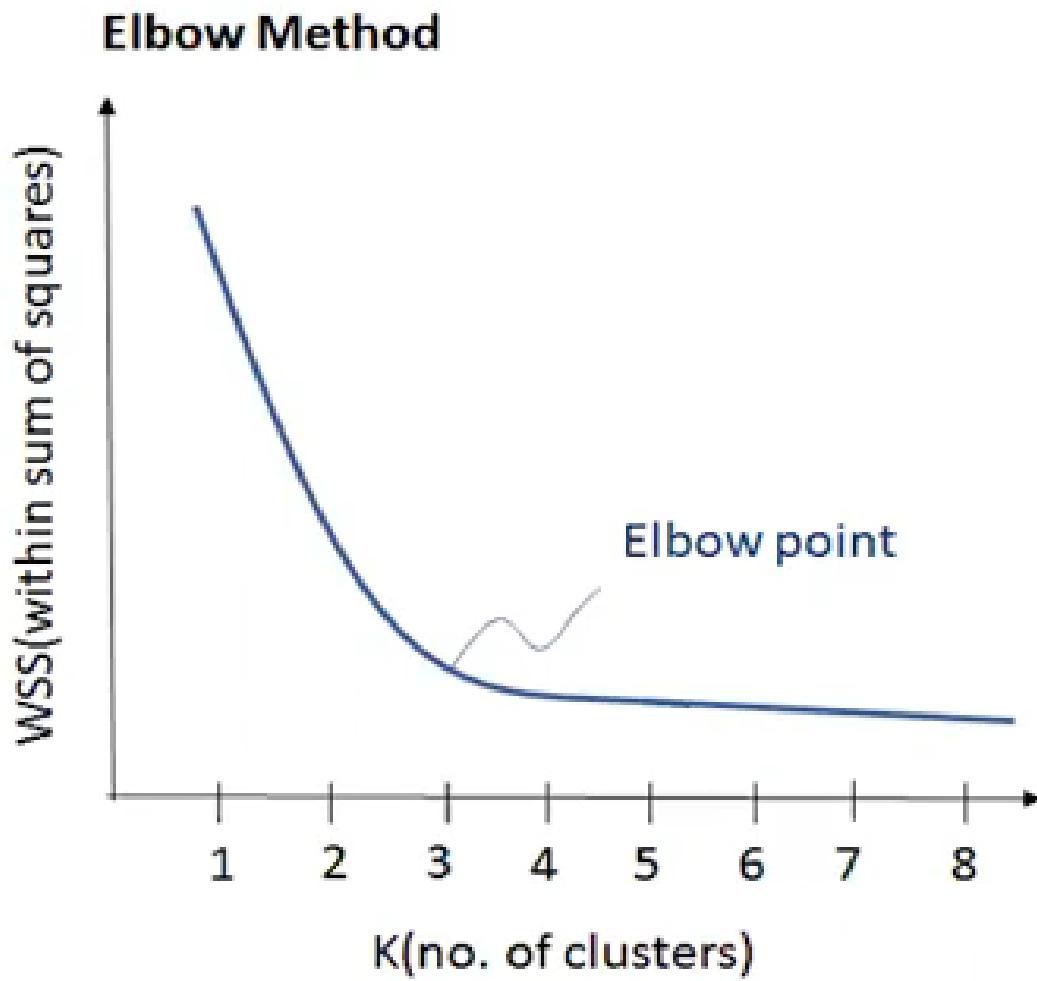
Multiple iterations



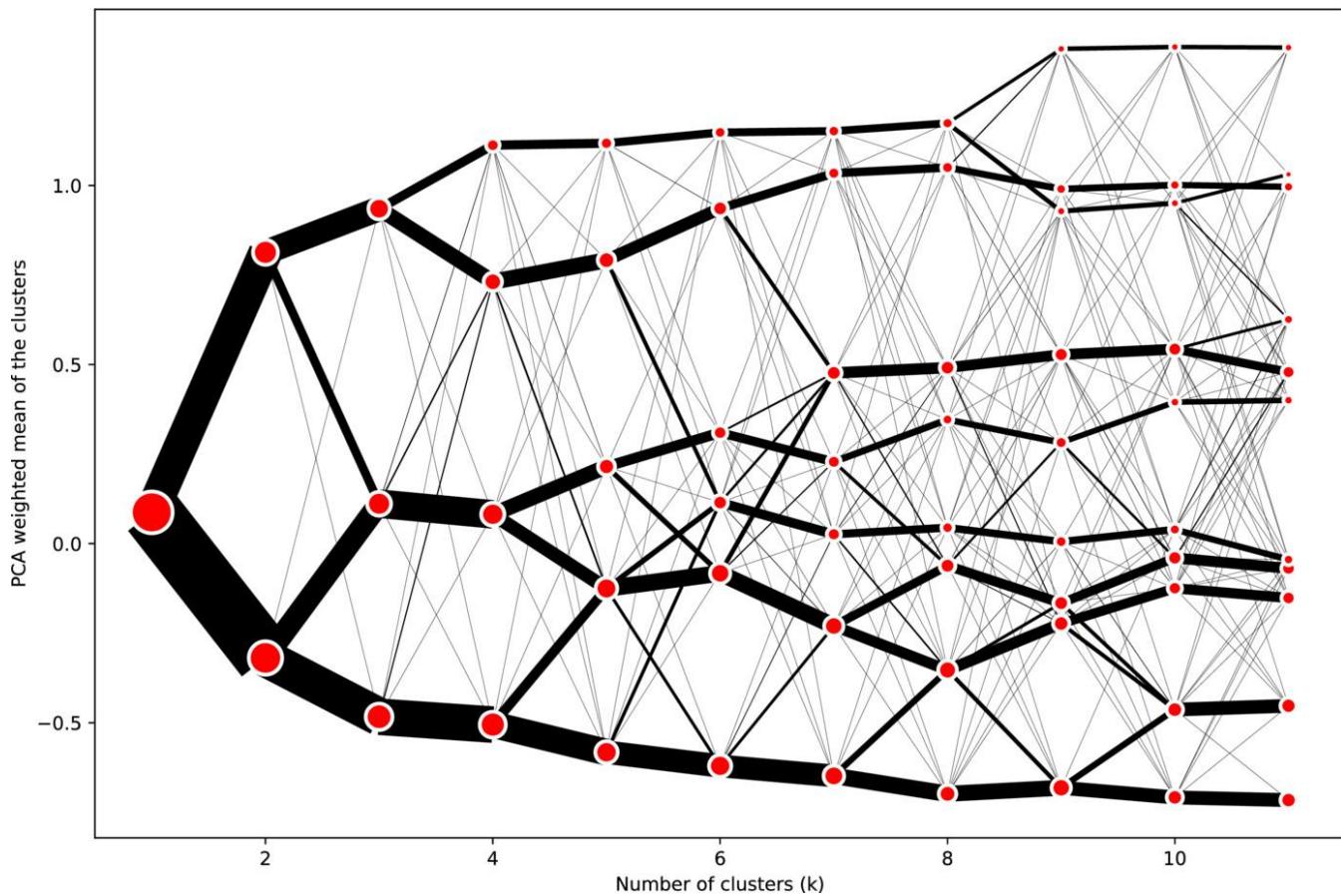
Number of clusters

- Too few: too much variation within the groups.
- Too many: overfitting and splitting similar observations.

Number of clusters



Number of clusters



Interpretation of clusters

- Look at the means of the input data for each cluster ('signature').
- Can use spider or bar plots to characterise the cluster.
- Not spatial in nature (different to the DBSCAN).

Cluster labels

- Should generalise the characteristics of each group.
- Should be clear for users unfamiliar with geodemographics.
- Should not cause offense to the inhabitants of each group.
- Should not draw on assumptions that cannot be applied by the data.
- Be aware of the unevenness of the ecological fallacy.
- Create pen portraits for easy interpretation.

Conclusion

- Geodemographics as the analysis of people by where they live.
- Typically, a form of unsupervised machine learning is used.
- Once created: **benchmarking** against additional quantitative data.
- Sometimes the spatial scale should be re-considered.
- Recent classifications: London Output Area Classification 2021, Output Area Classification England and Wales 2021, UK Output Area Classification 2021.

Computer practical

The screenshot shows a web browser window with the URL jtvandijk.github.io/GEOG0114/. The page title is "Principles of Spatial Analysis". The left sidebar contains navigation links for "Module overview" (with "Welcome" selected), "Applied Spatial Analysis" (with "Geodemographic Classification" and "Accessibility Analysis" listed), and search icons. The main content area features a large image of a laptop displaying code in a terminal window, resting on a desk next to a stack of books. To the right of the image is a sidebar titled "On this page" with links to "Principles of Spatial Analysis", "Major updates", and "Acknowledgements", and a "Report an issue" button.

Week	Section	Topic
1	Foundational Concepts	Spatial analysis for data science
2	Foundational Concepts	Graphical representation of spatial data
3	Foundational Concepts	Spatial autocorrelation
4	Raster data	Suitability Mapping I

Questions

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