- **Towards Electronic Democracy**

TED 06

Towards e-Democracy: Participation, Deliberation, Communities
Mantova, Italy
24 - 26 October, 2006

<>

Direct Democracy for Complex Decision Making using ICT

Francis McGonigal
Department of Computing
Business School
University of Central England in Birmingham

Representative Democracy

- Representative Democracy:
- Election of
  - Councillors
  - Legislators
  - Presidents

Representative Democracy

- Systems of Representative Democracy:
- ‘First Past the Post’ or ‘Simple Majority’
- Supplementary Vote
- Proportional Representation
- Single Transferable Vote……etc.

Direct Democracy

- Direct democracy refers to a vote directly by the electorate on an issue
- Widely used in
  - Switzerland
  - Many states of the USA, particularly California.

Direct Democracy

- In the UK
  - Northern Ireland border poll in 1973,
  - UK-wide referendum on the EEC (1975),
  - devolution
  - elected mayors
  - Council Tax proposals.

Direct Democracy

- In most cases
  - straightforward votes to accept or reject a specific proposal.
- In some cases
  - related questions, for example
  - Scottish devolution referendum supplementary question on tax-raising powers.

Direct Democracy

- Recent examples with several options:
  - Refernda held by various English local authorities

  Milton Keynes, Bristol and Croydon

  on proposed Council Tax increases.
- Voters may be asked for one preferred option OR an order of preference

Direct Democracy

- <u>Problems</u>
- **California's 'Insurance Wars' of 1988 Five conflicting propositions (concerned with insurance) were offered to voters.**

Direct Democracy

- **What if two contradictory propositions are both passed**?
- **Were various propositions a tactical manoeuvre (by the industry) to thwart the consumers' proposition**?

Direct Democracy

- What if..?
  – The range of choices is much greater, such as:
  - allocating funds between several contending projects.
  - Setting several rates of tax.
  - Any complex decision!

Direct Democracy

- Analogy with Representative Democracy,
- alternative options or ‘Courses of Action’ takes the place of ‘candidates’.
- Then the relative merits of voting systems can be considered

Direct Democracy

- However,

- 'Courses of Action' may be very numerous and complex.
- Setting of two rates of tax might allow hundreds of possible options.

Inherent Problems of Democracy

- Condorcet's Paradox
  - Preferences of each individual are transitive
    prefer A over B and B over C;
    therefore A over C .
  - Preferences of the majority can be intransitive
    a majority of voters may
    choose A over B, B over C
    but C over A.

Inherent Problems of Democracy

- Utilised in Arrow's Impossibility Theorem

  It is not, in general, possible to construct social preferences (i.e. a voting system) from individual preferences

  such that

  certain intuitively reasonable axioms are satisfied.

Inherent Problems of Democracy

- No 'perfect' voting system;
- any system will involve trade-offs between various desirable features.
- Even breaking a problem down to a series of yes-no questions can cause problems

Condorcet Winner

- In many cases there will be one option (called the Condorcet winner)
  - which would be preferred
    to any other option
    in a one-to-one contest.

Condorcet Winner

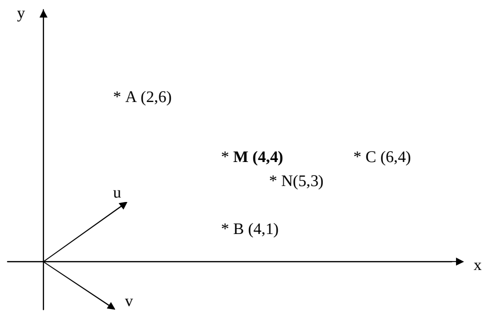
- With a large number of voters the probability of a Condorcet winner emerging declines with the number of options available to choose from.

The Median Voter Theorem (Downs, 1957 and Black, 1958)

- One class of problems which will always have a Condorcet winner.
- Where voters' positions lie on a one-dimensional scale (for example Left-Right in politics) then the median of the votes' positions will be the Condorcet winner.
- Certain conditions apply!

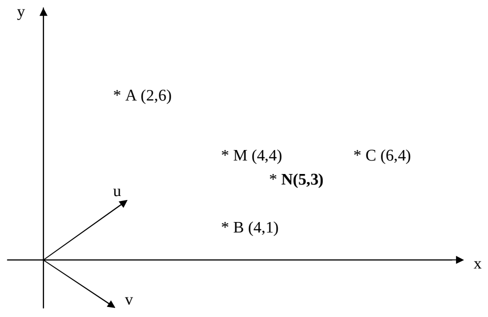
The Median Voter Theorem

- Can it apply in two dimensions?



The Median Voter Theorem

- Clearly changing axis gives different results.



The Median Voter Theorem

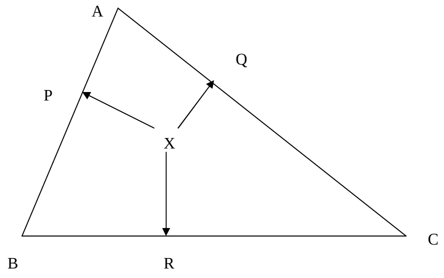
- Euclidean distance used as a measure of closeness between positions

  - in general there is still no Condorcet winner, unless the voters' positions line up in a very specific way

  (Miller, Grofman and Feld 1989).

The Median Voter Theorem

- VERY simple example
- Three voters A B C.



Condorcet Winner

- **Whatever algorithm is used to select the winner,**

  there will be always be:
- **some other position that is preferred by a majority**

(except in very specific circumstances).

Condorcet Winner

- In any case:
- Finding a Condorcet winner, is not necessarily the only criteria for choosing the preferred option. For example
- in issues of public spending proportionality between interest groups may be a factor.

More Problems

- Practical
- If voters have a choice of say ten candidates, it may be reasonable to ask them to choose their preferred candidate or to rank them in order of preference.

More Problems

- If there are thousands of options, it would not be practical to expect voters to give every option a rank or score.
- On the other hand just asking voters for their first choice of options may deprive us of useful information.

More Problems

- In very complex system, we could find that one individual that is most ‘typical’ of the group
- Then we might as well elect a Representative, not have Direct Democracy.

More Problems

- BUT
  - If we elect a Representative, then there may always be some issues on which
  - The Majority disagrees with that elected Representative.

Approaches to problems

- Techniques from Operations Research
- Multi-Criteria Decision Analysis
- Saaty's Analytical Hierarchy Process
  - (Saaty 1980)

Analytical Hierarchy Process

- AHP uses paired comparisons between different *criteria*.
- The decision maker expresses some degree of importance of one criterion over another.

Analytical Hierarchy Process

- From the normalized matrix of the pairwise comparisons, the process calculates a priorities vector which gives a numerical score to each criterion.

Analytical Hierarchy Process

- The vector is the principal eigenvector of the normalized matrix which gives a numerical score to each *criterion*.

Analytical Hierarchy Process

- How does it help with direct democracy?
- A voter may not be able to give a rank or score to thousands of options BUT
- May be able to express pairwise comparison between a small number of criteria.
- The system can then calculate scores, for the individual voter, for each proposal.

Analytical Hierarchy Process

- The system can then determine the winning proposal(s) depending on what Voting Rule is used .

Example: Budget Proposals

- Suppose we have:
- m persons
- q proposals, $a_{1 \ldots} a_q$ each with cost c_i
- Each person evaluates each proposal according to a number of criteria
- $X_{i,j,k}$ = value given to proposal i by person j according to criterion k.
- Total budget available = b
- Rios, J., Rios Insua, D., Fernandez, E. and Rivero, J.A. (2005)

Example: Budget Proposals

- Rios et. al. (2005) describe a web-based system for participatory budget formation.
- Attempt heuristic approach to finding negotiated solution using modified *balanced increment method*.
- If agreement is not reached, decision is by approval voting.

Example: Budget Proposals

- Relevance for Direct Democracy:
- With a large number of voters it is unlikely that consensus (unanimity) will be reached.
- Approval Voting may disadvantage minority interest groups, for example if the community is divided 60%-40%.

Example: Budget Proposals

- Possible Alternative (by analogy with Representative Democracy):
- Consider proportional systems used to elect Legislatures and Councils.
- Parties or Interest Groups could put forward *ordered list* of proposals
- Each Voter selects one list
- Each list has share proportionate to vote.

Example: Budget Proposals

- Another Alternative
- Lists would not allow voter to express preferences between each proposal.
- One system which eliminates the need for lists is Single Transferable Vote (used in Ireland and Malta)
- Could it be adapted for Budget Formation?

Example: Budget Proposals

- Major difference: In election of people each candidate is ONE person, in budget formation proposals have DIFFERENT COSTS.
- If number of budget proposals is large then each voter's schedule of preference may be calculated
- EITHER using weightings given explicitly by the voter according to criteria
- OR using a technique such as AHP.

Example: Budget Proposals

- Rather than ask:
- "What is voter's 1st , 2nd , 3rd preference
- ASK
- "Where is voter's 1st € allocated, 2nd € allocated, next € etc.

Principles of STV:

- Surplus votes of successful candidates; or eliminated candidates are TRANSFERRED to voter's next preference.
- A calculated QUOTA is required for candidate to be elected (or proposal approved)

Example:

Six budget proposals

PROPOSAL	COST					
A	€ 4,000					
B	€ 9,000					
C	€ 2,000					
D	€ 3,000					
E	€ 5,000					
F	€ 1,000					
TOTAL	€ 24,000					
Available	**€ 15,000**					

Five Voters.

First consider each voter's first €3,000, equivalent to the total of €15,000 budget available (shaded areas).

This is similar to considering First Preference votes.

value	voter	SCHEDULE	SCHEDULE																			
			1st €5,000					2nd €5,000					3rd €5,000					4th €5,000				
€ 3,000	1	ABCDEF	A	A	A	A	B	B	B	B	B	B	B	B	B	C	C	D	D	D	E	E
€ 3,000	2	BCDAEF	B	B	B	B	B	B	B	B	B	C	C	D	D	D	A	A	A	A	E	E
€ 3,000	3	DACBEF	D	D	D	A	A	A	A	C	C	B	B	B	B	B	B	B	B	B	E	E
€ 3,000	4	EDBACF	E	E	E	E	E	D	D	D	B	B	B	B	B	B	B	B	B	A	A	A
€ 3,000	5	ECBDAF	E	E	E	E	E	C	C	B	B	B	B	B	B	B	B	B	D	D	D	A
€ 15,000																						

First count

	VOTE		QUOTA	SURPLUS	
A	€ 3,000	A	€ 4,000		
B	€ 3,000	B	€ 9,000		
C	€ 0	C	€ 2,000		
D	€ 3,000	D	€ 3,000	€ 0	**elected**
E	€ 6,000	E	€ 5,000	€ 1,000	**elected**
F	€ 0		€ 1,000		
	€ 15,000		€ 24,000		

D is elected with no surplus

E is elected with surplus of €1,000

Redistribution of votes

		value	voter	SCHEDULE	SCHEDULE													
					1st €2,500					2nd €2,500					3rd €2,500			
		€ 3,000	1	ABCF	A	A	A	A	A	A	A	A	B	B	B	B	B	B
		€ 3,000	2	BCAF	B	B	B	B	B	B	B	B	B	B	B	B	B	B
		€ 0	3															
3000*(1000/6000)=		€ 500	4	BACF	B	B	B	B	B	B	B	B	B	B	B	B	B	B
3000*(1000/6000)=		€ 500	5	CBAF	C	C	C	C	B	B	B	B	B	B	B	B	B	B
		€ 7,000																

Voter #3 takes no further part as their vote was used exactly with no surplus.

Voters #4 and #5 whose first choice was E have their votes transferred to their next preferences, but only in proportion to their surplus

Second count

	VOTE		QUOTA	SURPLUS		
A	€ 3,000	A	€ 4,000			
B	€ 3,500	B	€ 9,000	**€ 3,500**	**eliminated**	
C	€ 500	C	€ 2,000			
D	**elected**	D				
E	**elected**	E				
F	€ 0	F	€ 1,000			
	€ 7,000		€ 16,000			

B needs €9,000 but only €7,000 is still available.

So B is eliminated, and the €3,500 voted to B is transferred

to next preferences

Redistribution of votes

value	voter	SCHEDUL	SCHEDULE											
			1st €2,500					2nd €2,500					3rd	
€ 3,000	1	ACF	A	A	A	A	A	A	A	A	C	C	C	C
€ 3,000	2	CAF	C	C	C	C	A	A	A	A	A	A	A	A
€ 0	3													
€ 500	4	ACF	A	A	A	A	A	A	A	A	C	C	C	C
€ 500	5	CAF	C	C	C	C	A	A	A	A	A	A	A	A
€ 7,000														

Note that Voter #2 has the first €3,000 of preferences divided between C and A

Third count

CANDIDATE	VOTE		QUOTA	SURPLUS	
A	€ 4,500	A	€ 4,000	€ 500	**elected**
B	eliminated	B	€ 9,000		
C	€ 2,500	C	€ 2,000	€ 500	**elected**
D	**elected**	D			
E	**elected**	E			
F	€ 0	F	€ 1,000		
	€ 7,000		€ 16,000		

Redistribution of votes

	value	voter	SCHEDULE	SCHEDULE										
				1st €500										
3000*(500/4500)	€ 333.33	1	F	F	F	F	F	F	F	F				
2000*(500/2500)+1000*(500/4500)	€ 511.11	2	F	F	F	F	F	F	F	F	F	F	F	F
	€ 0.00	3												
500*(500/4500)	€ 55.55	4	F	F	F									
500*(500/2500)	€ 100.00	5	F	F	F									
	€ 1,000													

Note: Calculation of Voter #2 value is complex because it was split between A and C

Shaded areas are only approximate.

Calculations are shown as examples, but as F is the only remaining candidate it takes the remaining votes.

Fourth count

CANDIDATE	VOTE		QUOTA	SURPLUS	
A	**elected**	A			
B	eliminated	B			
C	**elected**	C			
D	**elected**	D			
E	**elected**	E			
F	€ 1,000	F	€ 1,000	€ 0	**elected**
	€ 1,000		€ 1,000		

Problems with STV for budgets

- In the preceding example F was elected although it was least popular.
- BECAUSE it had a small cost and took the last €1,000.
- In this case the whole budget was used, but there could be a small amount left.

Problems with STV for budgets

- We took quota to be simply the required proportion of the budget for each proposal.
- In real STV it is slightly less (the ‘Droop Quota’), and obviously the same for each candidate.

Problems with STV for budgets

- In real STV, if no candidate reaches the quota in a given count, the next step is to eliminate that candidate with the fewest votes.
- In adapting STV for budgets we eliminated one proposal whose cost was greater than the money remaining.
- If no proposal is eliminated or elected as above, we also need a rule to eliminate one with the lowest votes *proportionate* to its cost.

Other approaches

- Techniques from AI
  - Machine learning: Use partial information to ascertain preferences of Individual or Group
  - Limited number of test cases.
  - May be applicable for Tree Structures?

ID3 Algorithm

- One technique for Concept Learning
- Generates Decision Tree from ‘training data’.
- Uses statistics to deal with noise or errors in data.
- Uses a concept of ‘Information Gain’ to optimize decision tree.
- Quinlan, J.R. (1986)

ID3 Algorithm – example.

Membership of a Professional Organization.

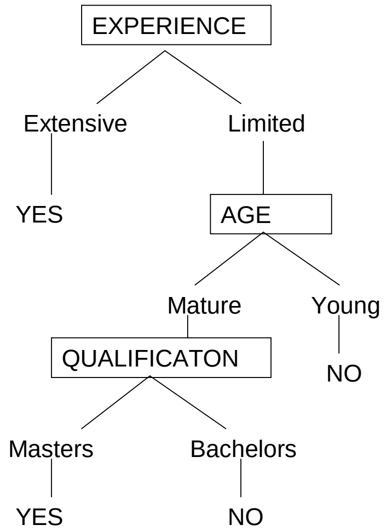
Five test cases, using three criteria:

Instance	Age	Experience	Qualification	Classification
1	Mature	Limited	Masters	**YES**
2	Mature	Limited	Bachelors	**NO**
3	Young	Extensive	Masters	**YES**
4	Young	Extensive	Bachelors	**YES**
5	Young	Limited	Masters	**NO**

ID3 will generate the decision tree, which can then be applied to new cases.

In this simple example only eight possible cases.

Decision tree



ID3 Algorithm

- <u>How does it help with direct democracy?</u>
- Decisions have to be made about criteria for citizenship, residence, grades of membership in organizations, grants.. etc.
- Each individual has there own criteria or ‘tree structure’ BUT
- May articulate this better through examples.

ID3 Algorithm

- <u>How does it help with direct democracy?</u>
- Panels of citizens or members of an organization could generate a collective Decision Tree from a number of test cases.
- Direct vote on each test case.
- OR each person generates individual tree, which is then used to 'vote' on new cases

ID3 Algorithm

- ALTERNATIVE APPROACH.

- each person generates individual tree, which is then used to 'vote' on new cases

REFERENCES

- Albert, M. and Hahnel, R. (1991). *The Political Economy of Participatory Economics*.
- ISBN: 069100384X. Princeton University Press
- Black, Duncan. (1958). *The Theory of Committees and Elections*. London: Cambridge. Cited in (Groseclose 1999).
- Day, William H. E. and McMorris, F.R.(2003). *Axiomatic Consensus Theory in Group Choice and Biomathematics*. ISBN: 0898715512. Philadelphia: SIAM (Society of Industrial and Applied Mathematics).
- Downs, A. (1957) *An Economic Theory of Democracy*. New York: Harper Collins. Cited in (Groseclose 1999).
- Budge, I. (1996) *The new challenge of direct democracy*. ISBN: 0745612318.
- Cambridge: Polity Press.

REFERENCES

- Felsenthal, Dan S. and Machover, Moshé (1992). *After Two Centuries,* Should Condorcet's
- Voting Procedure Be Implemented. Behavioral Science 37:4 (October 1992), 250–274.
- Groseclose, Tim (1999). 'One and a Half Dimensional' Preferences and Majority Rule.
- Graduate School of Business Stanford University 13 May 1999.
- Hill, I. D., Wichmann, B.A. and Woodall, D.R. (1987) Algorithm 123 —Single Transferable Vote By Meek's Method. Computer Journal, Vol. 30 No III.
- Insua, D.R.; Holgado, J. and Moreno R. (2004) Multicriteria e-negotiation systems for e-democracy. Statistics and Decision Sciences Group Universidad Rey Juan Carlos.
- Lacy, Dean and Niou, Emerson M.S. (1998) *A Problem with Referendums*. The Political Economy Working Papers Archive, University of Michigan.
-

REFERENCES

- Maassen, J.D.M. & Bezembinder, T.G.G. (2002). Generating random weak orders and the probability of a Condorcet winner. Social Choice and Welfare, 19 (3), 517-532.
- McLean, I & London, J. (1990) The Borda and Condorcet principles: three medieval applications. Social Choice Welfare, 7 (1990), 99-108. Cited in (Day and McMorris 2003).
- Miller, Nicholas R.; Grofman, Bernard and Feld, Scott L.(1989) "The Geometry of Majority Rule". Journal of Theoretical Politics, 1 (October, 1989): 379-406.
- Mueller, Dennis C. (1989) Public Choice II ISBN:0521379520. Cambridge University Press.
- Mueller, Dennis C. (2003) Public Choice III ISBN:0521894751. Cambridge University Press.
- Plott, Charles. (1967). "A Notion of Equilibrium Under Majority Rule," American Economic Review. 57: 787-806. Cited in (Groseclose 1999).

REFERENCES

- Quinlan, J.R. (1986) Induction of Decision Trees. Machine Learning 1(1), pages 81-106.
- Riker, W.H. (1982). Liberalism against Populism (San Francisco, Freeman).
- Cited in (Budge 1996).
- Rios, J., Rios Insua, D., Fernandez, E. and Rivero, J.A. (2005) Participatory Budget Formation Through the Web. E-Government: Towards Electronic Democracy International Conference Bolzano Italy March 2005.
- Saaty T.L. (1980) Multicriteria Decision Making: the Analytic network process; McGraw-Hill: New York. Cited in (Moreno-Jiménez & Polasek , 2003)
- Schofield, Norman. (1983). "Generic Instability of Majority Rule," Review of Economic
- Studies. 50: 696-705. Cited in (Groseclose 1999).
- Zycher, Benjamin (1990). Automobile Insurance Regulation, Direct Democracy, and the Interests of Consumers. Regulation Volume 13, Number 2, Summer 1990.