An automatic seating plan algorithm

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An appropriate seating plan is an important prerequisite for any good party be it a formal wedding or an informal dinner. Yet anyone who has designed a seating plan knows that it can prove frustratingly difficult to find a solution that solves the large number of formal, physical and personal constraints associated. Below I present a flexible algorithm for automating the task.

Each seat and guest is represented by a number between 1 and N, and the seating problem is equivalent to provide a map between guest numbers and seat numbers. The physical layout of the tables is represented by a connectivity matrix, C, that contain information about the extent of interaction possible between pairs of seats. Neighbours have $C_{ij} = 1$ whereas for distant seats, e.g. on different tables, $C_{ij} = 0$. Additional pairs of seats, e.g. on opposite sides of a table, can have non-zero values of C_{ij}. C is specified as input to the algorithm and can for most layouts easily be prepared automatically.

The psychological aspect of the interaction between people is represented by a 'dissimilarity' matrix, D, in which the elements D_{kl} indicate how suitable it is to place guests k and l next to each other and with low values

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indicating good compatibility. D is used as input to the algorithm, but for large numbers of guests is inconvenient to specify manually. A simple solution is to assign all pairs a default value automatically and only to edit significantly (un)favourable pairs. An alternative and efficient method is to represent the 'personality' of each guest, k, by a vector p_k, possibly as a series of numerically encoded answers to questions designed to classify personality[1]. This approach is particularly suitable in the case where guests k and l have never met each other. The dissimilarity between two guests can then be calculated by using a functional, f: $D_{kl} = f(p_k, p_l)$. In the case of p_k consisting of answers to binary yes/no questions, f could count the number of answers that differ between guests k and l.

The overall '(un)fitness' of any given seating plan can be calculated from the connectivity and dissimilarity matrices C and D as a sum over all pairs of seats:

$$E = \sum_{seats=i,j}^{N} C_{ij} D_{kl} \quad (1)$$

where $k(l)$ is the guest number seated at seat $i(j)$. Thus, in the calculation of E the dissimilarity between guests k and l (D_{kl}) is weighted by their physical distance in the seating plan (C_{ij}). By introducing Eq. 1 the problem of finding a good seating plan becomes equivalent to minimizing E.

The above definition of a good seating plan is very flexible and allows for the introduction of many additional types of requirements. For example it is often attempted to prepare a seating plan with alternating sexes as neighbours. This is easily implemented by adding a penalty to E for each pair of neighbours that are of the same sex. Another common situation is that certain guests are to be seated at particular seats, and can be dealt with similarly.

For small numbers of guests the seating plan(s) that minimize E can be found by a full combinatorial sampling. However, this method quickly becomes intractable and instead requires a numerical approach. The present formulation of the problem has many similarities to vector models of the

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physics of systems of interacting spins. Based on this analogy, good seating plans are found using an iterative Monte Carlo approach, in which a new seating plan is generated from the previous plan by swapping guests and accepting or rejecting the resulting change in E by the Metropolis criterion[3]. In combination with a simulated annealing protocol[2] that progressively diminishes the size of changes that are allowed, this procedure allows for the determination of good solutions to the seating plan problem.

The algorithm described above provides a method for finding a seating plan given a particular layout of tables. This directly suggests an extension in which it is left to the algorithm to determine an optimal layout of tables, i.e. to optimize the connectivity matrix C: First a new trial table layout is generated from the previous one and C updated. Secondly, using the procedure described above, a good seating plan is determined given the trial table layout. The new trial layout is then judged by the Metropolis criterion and a simulated annealing protocol is used to find an optimal layout of tables. The results of one such simulation is shown in Fig. 1.

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Figure

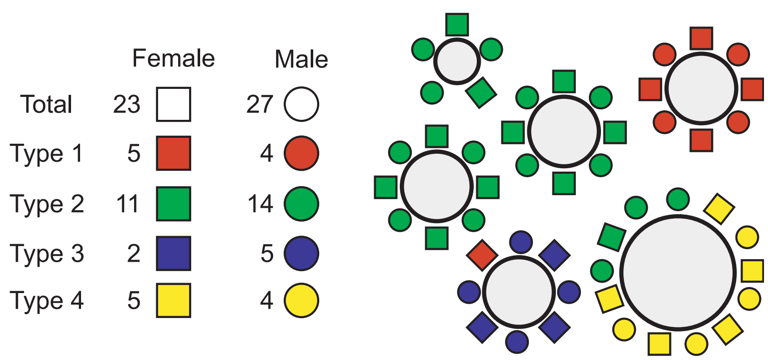

Figure 1: Automatic generation of a good seating plan and table layout. 50 'hypothetical' guests were assigned a sex (squares or circles) and a personality type (colours) as described in more detail in the supplementary material. Apart from that encoded in D, no information about type was used as input to the algorithm. It is clear that the algorithm effectively provides a seating plan were nearly all guests are seated both in an environment with the same type of personalities and next to a guest of the opposite sex.

Methods

For the data in Fig. 1, each of 50 hypothetical guests were at random assigned a sex with the probability of choosing a male guest being 55%. This resulted in 23 female and 27 male guests. Each guest was assigned to one of four personality types with the following probabilities: type 1 (20%), type 2 (40%), type 3 (20%) and type 4 (20%). For guests with the same personality type the elements of the dissimilarity matrix, D, were chosen as random numbers drawn from a normal distribution with mean 0.25 and standard deviation 0.1. For guests belonging to different types D was sampled from a normal distribution with mean 0.75 and standard deviation 0.25. Additionally, a penalty of 2 was assigned to each pair of neighbours with the same sex.

Good table layouts were found using a simulated annealing procedure in which the effective temperature was decreased from 5.0 to 0.5 in 5 steps. At each temperature 50 different table layouts were tested. Round tables were allowed to have between 5 and 15 seats. For neighbours $C_{ij} = 1$ whereas for guests at different tables $C_{ij} = 0$. For non-direct neighbours on the same table C_{ij} was chosen to be inversely related to the size of the table and were scaled so that no particular table size was favoured.

For each trial table layout, a good seating plan was determined using a simulated annealing procedure in which the effective temperature was decreased from 0.5 to 0.1 in 5 steps. At each temperature, 500 different seating plans were tested.

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