MODELLING THE OPTIMUM LEVEL OF INFORMATION TRANSFER IN RADIO COMMUNICATION

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Information that is broadcast live via radio involves complex human interactions between the sender and the receiver. The work done in radio programs benefits and builds upon numerous scientific studies conducted in fields like natural language processing, emotional and prosodic modelling, as well signal processing. With a view to all of the above, this article focuses on the means by which direct verbal communication characteristic of radio broadcasts can be made more efficient by optimizing the level of information conveyed by new messages, considering the level of information absorption on behalf of radio audience.

Key words: *radiophony, hybrid algorithm, optimization.*

1. INTRODUCTION

The evolution of media from the written form, to radio and TV broadcast, as well as to online and social media has increased the level of interest in accessing media content, and concomitantly has augmented information flows quantity, quality and transmission speed. Verbal language is the main communication means. All the more, in radio communication which is based on direct verbal exchange, information transfer, regardless of its unidirectional or bidirectional character, needs to comply with the standards of a field that is exclusively, systematically and scientifically focusing on the former's aspects [1].

Radio communication is viewed as the fastest "mass communication" channel given the reduced processing speed, as well as the short timeframe required to obtain information and then to broadcast it. Thus, the listeners need to feel that the content of messages is directed at them. Therefore, the messages that are broadcast and received need to be first of all correct, coherent and dynamic, grammatically and stylistically speaking. It is obvious that optimal unidirectional communication needs to observe the meaning of the text that is read, without distorting it by using tendentious intonation. Apart from the prosodic parameters of communication, the pace and speed used to read a text are important. Reading too fast, makes the message difficult to follow, whereas a too slow pace makes it boring. A sustained tempo provides the necessary tension and increases interest. However, if maintained for too long it can become tiresome [2]. Thus the speed of the message needs to fit its content and type, since any mismatch gives the feeling of artificial and unprofessional. The pauses made while reading messages need to render its tempo and underline the most important ideas, while also giving time to the audience/interlocutors to understand and conceive an internal/explicit message. Moreover, stressing key words along with the conveyance of emotional messages should not go beyond a certain limit.

All of the above considered, the notion of direct information sent via radio is very general. Hence, measuring it and deciding the optimal level for transferring messages are required. Given the existence of two messages concerning the same event in radio based communication, several questions emerge:

a. Which of the two messages gains greater amplitude?

b. Which of the two messages is more important and, thus, more useful?

c. How complete is a certain message?

d. What is the level of redundancy, as far as the listener is concerned?

e. How much and what does a listener perceive/retain from an information package?

In both cases, the comparison between the two messages requires a system to quantify the amount of information obtained as a result of an event in order to exclude the uncertainty as to whether the event took place or not [3]. Moreover, approaching radio communication from a cybernetic perspective, namely as a system that is self-organized via feedback, it is necessary to model the latter's evolution in terms of the constraints generated by the rate of information absorption on behalf of the audience or a by the resource consumption triggered by information aggregation and conveyance.

As part of a general information transfer process, the methods by which optimal technical solutions can be found consist in first establishing some so called "objective functions and constraints". An objective function is the mathematical expression of the quantitative influence of the most significant parameters on system quality. Constraints are functions that limit the level of variation that is accepted for an objective function and system parameters. In order to find optimal technical solutions, that is the constraints that match the maximum and minimum levels of the objective function, the latter needs to be investigated through analytical and numerical optimization methods [4].

2. A HYBRID ALGORITHM FOR CONSTRAINTS BASED OPTIMIZATION

The first optimization model proposed by this article is derived from the nonderivative models that are used do deal with a relatively small number of variables. These methods are based on bracketing a number of points along which the values generated by the minimization of function decrease. Moreover, the methods are characterized by the fact that the algorithm that determines the minimum is only built on the values of the objective function with no estimation procedure in place, nor with any use of the information from the derivative of the function that would determine an upward direction [5]. Given a current point xc for each iteration and an xt test point, the algorithm needs to determine the acceptance of this point (x+=xt) or its rejection (x+=xc). Thus, the methods that are theoretically underpinned by the Karush-Kuhn-Tucker optimality conditions are considered primal–dual methods and they can be applied both as primal and dual variables. Consequently, for a problem with equality constraints (as it is the case with the optimization of the prosodic component):

min f(x) (1)

given the bounds:

$$r_i(x) = 0, \quad i = 1,\dots,m \qquad (2)$$

where functions f and r_i defined on R^n with real values, can be differentiated at least twice. Thus, such a method resides in solving the n+m equation system that is made of Karush-Kuhn-Tucker optimality conditions:

$$\nabla f(x) + \sum_{i=1}^{m} \theta_i \nabla r_i(x) = 0 \qquad (3)$$

$$r_i(x) = 0, \quad i = 1,\dots,m \qquad (4)$$

As for the unknown parameters x ∊ Rn and θ ∊ Rm, the previous system yields a solution by evaluating the Hessian matrix of the Lagrangian function, which is a rather difficult method. Therefore, one can continue with a Newton type method. In the case of inequality like bounds for the same function (with the same properties):

min f(x) (5)

given the bounds:

$$r_i(x) \le 0, \quad i = 1,\dots m \qquad (6)$$

the Karush-Kuhn-Tucker conditions that need to be solved are:

$$\nabla f(x) + \sum_{i=1}^{m} \theta_i \nabla r_i(x) = 0 \qquad (7)$$

$$\le 0, \quad i = 1,\dots,m; \quad \theta_i \ge 0, \quad i = \qquad (8)$$

$$\theta_i r_i(x) = 0 \qquad (9)$$

To solve this nonlinear system one can introduce a supplementary variable and then apply a Newton method. For any of the two situations, the model is linked to an amortized Newton algorithm. Thus, with every iteration, Newton step and decrement are computed, which involves determining the inverse Hessian matrix of the objective function (to be minimized).

The amortized Newton algorithm is:

Step 1: An initial x_0 ∊ *Dom f* point and tolerance $\varepsilon \ge 0$ are selected, where k = 0.

Step 2: Newton step is calculated:

$$p_{nt} = -\nabla^2 f(x_k)^{-1} \nabla f(x_k) \qquad (10)$$

Step 3: Newton decrement is computed:

$$d^2 = \nabla f(x_k)^T \nabla^2 f(x_k)^{-1} \nabla f(x_k) \qquad (11)$$

Step 4: If d2/2 ≤ ε, then STOP;

If not, step 5 is next.

Step 5: A linear search employing backtracking is conducted in order to find the tk size along Newton step.

Step 6: The approximation of the optimal point is updated:

$$x_{k+1} = x_k + t_k p_{nt} \qquad (12)$$

where k = k+1 and step 6 is executed [6].

3. A MODEL FOR OPTIMIZING THE AMOUNT OF INFORMATION TRANSFER

One approach to making verbal communication via radio efficient can focus on optimizing the level of information load conveyed through new messages by taking into account the capacity of retaining a whole package of messages on behalf of the audience. In more specific terms, the amount of information that is transmitted can also be viewed as the amount of editorial outputs (whether daily or based on a predetermined schedule) within a given timeframe [0,T].

The programming of information transmission process can be described by the equations below:

$$\frac{dC}{dt} = E - R; \quad \frac{dR}{dt} = -\alpha E \qquad (13)$$

where:

C(t) is the average amount of at t moment, in (bit);

R(t) is the average retention rate at t moment, in (bit/sec.);

E(t) is the average information transmission rate at t moment, in (bit/sec.);

$\alpha \geq 0$ is a constant.

The average rate E(t) at t moment can be controlled and can apparently increase in an uncontrolled manner. Moreover, the consumption of resources for broadcasting purposes is proportional to E^2. In this case, the objective is to determine by how much the average transmission rate can be improved in order to reflect a transfer leap from C(0) = C0; R(0) = R0 to C(T) = C1; R(T) =R1 within [0,T] time frame. All of that occurs while the average consumption of resources is kept to a minimum. That actually triggers a problem of optimal control where status variables are C and R, the command variable is E and the objective is to minimize the nonlinear function:

$$F(E) = \int_0^T [E(t)]^2 dt \qquad (14)$$

The Hamiltonian associated to this problem is:

$$H(t) = z_0(t)[E(t)]^2 + z_1(t)[E \qquad (15)$$

The command variable is not bounded by any increase constraints and hence needs to satisfy equations (13):

$$\frac{\partial H}{\partial E} = 2E(t)z_0(t) + z_1(t) - \alpha z_2 \qquad (16)$$

that upon yielding results generate the **optimal modality**:

$$E^*(t) = \frac{1}{2z_0^*(t)}[-z_1(t) + z_2(t)] \qquad (17)$$

where z_0^*, z_1^* and z_2^* are solutions of equations (16):

$$\dot{z}_0 = 0; \quad \dot{z}_1 = 1; \quad \dot{z}_2 = z_1(t) \qquad (18)$$

By integrating these equations, we obtain:

$$\dot{z}_0 = a; \quad \dot{z}_1 = b; \quad \dot{z}_2 = bt + c \qquad (19)$$

Where a, b and c are constants determined from the initial and final constraints on x0, C and R. Thus, necessarily the optimal modality is:

$$E^*(t) = \frac{\alpha b}{2a}t + \frac{\alpha c - b}{2a} \qquad (20)$$

That, when replaced by status equations, generates:

$$\dot{x}_0^* = \left(\frac{\alpha b}{2a}t + \frac{\alpha c - b}{2a}\right)^2; \quad \dot{R}^* = \qquad (21)$$

and

$$\dot{C}^{*} = \frac{\alpha b}{2a}t + \frac{\alpha c - b}{2a} - R^{*} \qquad (22)$$

The first two equations are integrated and thus we get:

$$x_0^{*} = \frac{\alpha^2 b^2}{12a^2}t^3 + \frac{\alpha b(\alpha c - b)}{4a^2}t^2 \qquad (23)$$

$$R^{*} = -\frac{\alpha^2 b}{4a}t^2 - \frac{\alpha(\alpha c - b)}{2a}t \text{ -} \qquad (24)$$

where d and e are constants of integration.

If x0(0)=0 and R0(0)=R0 and C(0)=C0, then d=0 and e=R0. By replacing these in equations (21) and (22) it results:

$$\dot{C}^{*} = \frac{\alpha^2 b}{4a}t^2 + \frac{\alpha^2 c}{2a}t + \frac{\alpha c - b}{2a} \text{ -} \qquad (25)$$

which, when integrated, results in:

$$C^{*} = \frac{\alpha^2 b}{12a}t^3 + \frac{\alpha^2 c}{4a}t^2 + \left(\frac{\alpha c -}{2a}\right. \qquad (26)$$

and yields the final conditions:

$C(T)=C_1$ și $R(T)=R_1$ (27)

and the following system results:

$$\begin{cases} \left(1 - \frac{\alpha T}{2}\right)\frac{b}{2} - \alpha\frac{c}{a} = \frac{2(R_1 - R_2}{T} \\ \left(\frac{\alpha^2 T^2}{b} - 1\right)\frac{b}{a} + \alpha\left(\frac{\alpha T}{2} + 1\right)\frac{c}{a} \end{cases} \qquad (28)$$

and $\frac{b}{a}$ and $\frac{c}{a}$ canbeidentified.

By introducing these into x, the optimality criterion can be deduced.

$$F(E^{*}) = x_0^{*}(T) = \left\{\frac{T^2}{4}\left(\frac{\alpha^2 T}{3} - \alpha + 1\right)\left(\frac{b}{a}\right)^2 + \frac{\alpha T}{4}(\alpha T - 1)\frac{b}{a}\frac{c}{a} + \frac{\alpha^2 T}{4}\left(\frac{c}{a}\right)^2\right\}\cdot k^2 \qquad (29)$$

where k is the factor of proportionality reflecting the average consumption of resources. Relation (29) provides the minimum value of average consumption of all emission resources.

4. CONCLUSIONS

Apart from eliminating uncertainty, information is also an interaction based on a communication process between a transmitter (radio) and receiver (radio audience).

The constrained hybrid optimization algorithm proposed solves the nonlinear system that is characteristic of information transfer general processes by introducing supplementary variables and, afterwards, applying an amortized Newton algorithm.

For any of the equal or unequal constraints, the solution to link the model that is theoretically underpinned by the Karush-Kuhn-Tucker optimality conditions with an amortized Newton algorithm manages to avoid rather complicated analytical procedures.

Building a model to program the process of information transmission helps quantifying the average emission rate. Thus, it reflects the transfer leaps among the information levels that are described by the quantity of transmitted information and the rate of information retention. Information transfer takes place under restrictive conditions that impose a minimum level in terms of the average consumption of all resources.

Thus, by optimizing the load of information that is transmitted on radio via new messages under the constraints imposed by information retention rate on behalf of receivers and the resources required for conceiving, editing, recording and conveying information, a more efficient process of direct communication via radio can be built.

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