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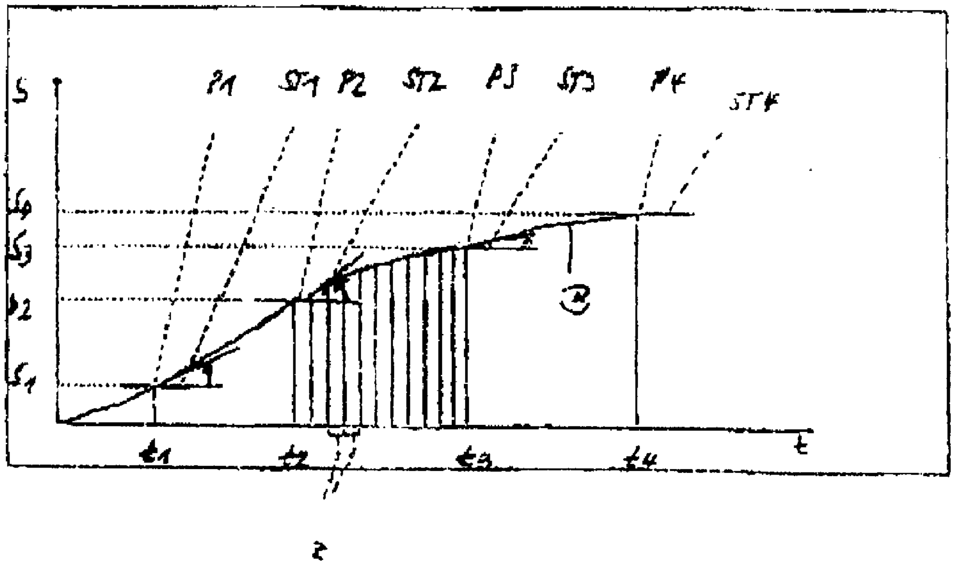
(54) **PROCEDE DE COMMANDE DECENTRALISEE D'UN ENTRAINEMENT DE MOTEUR**

(54) **METHOD FOR THE DECENTRALIZED CONTROL OF A MOTOR DRIVE**



(57) Dans la commande décentralisée d'un entraînement de moteur (1), auquel une unité de commande centrale (7) donne les instructions de mouvement sous forme de données d'espace et de temps pour des points de référence situés à distance les uns des autres (P1, P2, P3, P4), et auquel est subordonnée une unité de commande décentralisée intelligente (5), qui commande le moteur de façon que les instructions de mouvement soient exécutées, on obtient une commande ou une régulation exacte du trajet par le fait que l'on prédéfinit au moins un algorithme permettant de calculer une fonction spatio-temporelle pour l'unité de commande décentralisée (5), et que l'unité de commande centrale (7) transmet, en plus des données d'espace et de temps (s1, s2, s3, s4; t1, t2, t3, t4), au moins une information (ST1, ST2, ST3, ST4; sH; tH) permettant de calculer la fonction spatio-temporelle selon l'algorithme entre les points de référence (P1 à P4).

(57) The invention concerns the decentralized control of a motor drive (1) to which a central control unit (7) gives motion commands in the form of path and time data on reference points (P1, P2, P3, P4) located a certain distance apart, the drive having its own intelligent decentralized control unit (5) which controls the drive in such a way that the motion commands are executed. The invention ensures that the required path is followed by virtue of the fact that at least one algorithm for the calculation of a path/time function is defined for the decentralized control unit (5) and that, in addition to the path and time data (s1, s2, s3, s4; t1, t2, t3, t4), at least one item of information is transmitted by the central control unit (7) for calculation of the path/time function in accordance with the logarithm between the reference points (P1 to P4).

ABSTRACT

The invention concerns the decentralized control of a motor drive (1) to which a central control unit (7) gives motion commands in the form of path and time data on reference points (P1, P2, P3, P4) located a certain distance apart, the drive having its own intelligent decentralized control unit (5) which controls the drive in such a way that the motion commands are executed. The invention ensures that the required path is followed by virtue of the fact that at least one algorithm for the calculation of a path/time function is defined for the decentralized control unit (5) and that, in addition to the path and time data (s1, s2, s3, s4; t1, t2, t3, t4), at least one item of information is transmitted by the central control unit (7) for calculation of the path/time function in accordance with the logarithm between the reference points (P1 to P4).

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Method for the decentralized control of a motor drive

The invention relates to a method for the decentralized control of a motor drive which is prescribed movement tasks, in the form of path and time data for mutually spaced interpolation points, by a central controller, and which is assigned a intelligent decentralized controller which controls the motor drive such that the prescribed movement tasks are duly performed.

Such a method is disclosed, for example, in DE 41 08 074 C2. In this case, a motor drive is assigned a dedicated local intelligent controller which, in this case, is mounted directly on the housing of the motor drive.

The transmission of the movement tasks is performed such that data for interpolation points traversed by the motor drive are transmitted at very short intervals. Under the condition of a continuous connection of the respective curve segments between the interpolation points, the decentralized controller carries out the appropriate control of the motor drive. In this concept, the path curves executed between the interpolation points are largely arbitrary, with the result that a control which is as accurate as possible requires interpolation points to be transmitted at very short intervals, in particular if several motor drives exercise a common drive function, for example are to execute a prescribed two-dimensional or three-dimensional movement. It is therefore necessary to be able to transmit a large volume of data over the data bus between the central controller and the intelligent decentralized controllers of the individual motor drives, in order to keep the necessarily required inaccuracies between the interpolation points as low as possible.

The invention is therefore based on the problem of designing a method for decentralized control such that it is possible to achieve a high control accuracy even with a relatively small volume of data transmitted from the central control to the decentralized control.

Starting from this problem, a method of the type mentioned at the beginning is characterized according to the invention in that the decentralized controller is prescribed at least one algorithm for forming a path/time function, and in that in addition to the path data and time data, the central controller transmits at least one item of information for forming the path/time function in accordance with the algorithm between the interpolation points.

The method according to the invention is based on the fact that the decentralized control implements a path curve between the interpolation points which is uniquely prescribed by the central control. This means that the path curve effected by the motor control is defined in principle at all points, including between the interpolation points, and can be followed with arbitrary accuracy without the need for this purpose of transmitting gigantic volumes of data from the central control to the decentralized control. The concept of the invention offers the advantage that it is necessary to transmit interpolation points regularly only at relatively large intervals which can extend as far as into the range of tenths of a second, with the result that the spacing between the transmitted interpolation points is larger by orders of magnitude than the previous temporal spacing of transmitted interpolation points for a control which is halfway accurate.

Since it is possible in accordance with the invention to implement in principle any desired accuracy for the path curve effected by a motor drive, the invention can be used with particular advantage in the case of the cooperation between several motor drives for the purpose of handling or processing workpieces. The synchronization of the motor drives required for this purpose can be performed via an externally prescribed clock signal, via the data bus between the central controller and decentralized controllers or via a radio clock. The time between the synchronization signals can be bridged in this case by an internal clock with fine clock pulses which runs accurately between the synchronization signals.

In a preferred embodiment of the invention, data on the gradients of the path/time function at the interpolation points are transmitted as additional information. This can be performed by transmitting the gradient at the interpolation points as additional information in addition to the data of the interpolation points.

The additional information on the course of the curve can also come from the position of at least one highest point between the interpolations points which does not lie on the path curve. This is expedient, in particular, when Bezier curves are used as algorithm for the path/time function, and this is preferred because of the comparatively low computational outlay associated therewith. A further possibility for the use of auxiliary points arises when a spline B curve is applied.

The use of Bezier curves results in a minimum computational outlay when the position of the point of intersection of the tangents at the interpolation points is transmitted as additional information. The gradient of the path/time function at the interpolation points is characterized thereby, but only the information on a single auxiliary point is transmitted. In the numerical calculation of the Bezier curve in accordance with Casteljau, the calculation for this is performed in a single computational loop, with the result that what is required is a very slight computational effort which can be handled in a very short computational time.

The motor drive can follow the precalculated path curve by being controlled by the decentralized controller, the actual state being determined by path sensors of the motor drive and/or of the driven tool. Of course, it is also possible in this case to determine the actual state by means of a motor sensor integrated in the motor itself.

The control algorithm can be adapted in this case such that the current of the motor drive is controlled such that the precalculated path is followed as accurately as possible. By contrast to this, in the earlier technique the control algorithm was based on the optimum speed between two adjacent interpolation points.

The control can be carried out using known control algorithms, but also using fuzzy-logic controllers or the computational rules thereof. By concentrating the controller solely on driving precisely on the path/time function using simple control algorithms (for example P-controller, PI-controller etc.), the sampling rate can be increased by contrast with conventional systems in conjunction with the same computing power for the hardware used.

Owing to the slight possible path deviations because of the accurate path definition between the interpolation points, the accurate control onto the position when approaching the respective instant, and the rigorous temporal synchronization, a decentralized servodrive controlled in such a way can be used to achieve extremely high path speeds in conjunction with a low outlay on apparatus, even using comparatively simple and slow bus systems. Furthermore, it is possible to run a virtually arbitrary number of mutually synchronized axles by path control.

Owing to the decentralized structure, the drives can also be used for servoaxles with path control in the direct vicinity of the servomotors and their path-measuring systems, or even mechanically connected thereto. Given an appropriate structural design, it is possible thereby to avoid the interference signals which are otherwise emitted into the environment from long motor feed cables to which pulse-width-modulated signals are applied.

The operating principle according to the invention can also be used for controlled and uncontrolled stepping motors by controlling the stepping motor drive by means of a multiplicity of control steps between the interpolation points in accordance with the path/time function determined. A processor of the decentralized controller determines in accordance with the path/time function the appropriate instant for the next step of the stepping motor in the form of a control pulse, with the result that the stepping motor travels precisely along the calculated path curve. In the case of controlled systems, the load angle occurring can be corrected correspondingly.

Of course, the present invention can also be used to control or regulate linear motors.

By setting the current optimally for a precise travel along the path/time function, it is now possible even for motors which have an irregular torque development, for example reluctance motors, to be optimally controlled without the need for a complicated mathematical correction in the control, since the high sampling rate permits a rapid correction of the current setting actually required and capable of being determined at each new location.

If several axles arranged one behind another on at least one feed device, as is customary with woodworking machines for example, have to be controlled in temporal synchronism relative to the feed axle as a guide axis, said systems can be constructed very simply using a drive described. A particular advantage arises in this case when the paths to be travelled are generated by scanning a workpiece passing through at the inlet of the machine, and are already present as a path/time profile. It is then only necessary for this to be investigated with regard to the optimum position of the interpolation points and relayed to the decentralized drives.

The generation of path curves for processing or handling workpieces which are, for example, scanned by image-processing units or probes is also simplified and accelerated by the direct conversion into path/time functions for the respective decentralized controllers. This holds for one-, two- and three-dimensional measurements on workpieces. In the case of direct workpiece scanning using mechanical or optical probes or ones which operate similarly, it can suffice for the path/time function recorded during scanning to be adapted only to the optimum processing rate and the required cool corrections, and to transmit it to the decentralized drives without expensive further computational work.

In specific cases, it can be advantageous to equip the decentralized drives such that they automatically adapt the prescribed path/time functions to the current values as a function of, for example, speed-dependent signals of a guide axis, for example of a feed device. This means parameter-dependent modification of the data, transmitted by the central controller, for the interpolation points and the course of the curve between the interpolation points.

The invention is to be explained in more detail below with the aid of an exemplary embodiment represented in the drawing, in which:

Figure 1 shows a block diagram for a decentralized drive,

Figure 2 shows a diagrammatic representation for determining a path/time function on the basis of data transmitted for interpolation points,

Figure 3 shows a diagrammatic representation of the determination of the path curve using an auxiliary point.

Figure 1 shows a motor drive 1 having a drive shaft 2 and a path sensor 3, which is integrated in the motor drive 1 and can be designed as a position transducer or complete path-measuring system.

The motor drive 1 is connected to a decentralized intelligent controller 5 via a connecting cable 4. Said controller is connected, in turn, to a central controller 7, represented as a computer terminal, via a data bus 6.

Figure 2 shows a path/time diagram with four interpolation points P1, P2, P3, P4, whose associated coordinates s1, t1; s2, t2; s3, t3; s4, s4 [sic] are transmitted by the central controller 7 to the decentralized controller 5 via the data bus 6. According to the invention, an item of information is additionally transmitted on the gradient ST1, ST3 [sic], ST3, ST4 at the associated interpolation points P1, ... P4. The gradient values are represented in Figure 2 by tangents at the interpolation points P1, ... P4.

With a polynomial as algorithm, the data for the interpolation points s1, t1, ST1 ... can be used to determine the path curve B uniquely for practical purposes. It is shown for the interval t2-t3 that the control or regulation can be performed by the decentralized controller 5 at intervals Z which are very small by comparison with the interval t2-t3, with the result that it is possible to achieve an arbitrary accuracy for executing the path curve B by the motor drive 1.

Figure 3 illustrates as an example the determination of the path curve B between two interpolation points P1 and P2 using the coordinates sH, tH of an auxiliary point PH, which has been produced as the point of intersection of the tangents of the path/time function at the interpolation points P1 and P2. Using an iterative Bezier calculation, the path curve B is determined uniquely from said values for practical purposes, it being plain that the path curve runs through the interpolation points P1 and P2, but not through the auxiliary point PH. The use of a single auxiliary point PH for determining the path curve B leads to a very simple calculation with a short computing time.

Patent Claims

1. Method for the decentralized control of a motor drive (1) which is prescribed movement tasks, in the form of path and time data for mutually spaced interpolation points (P1, P2, P3, P4), by a central controller (7), and which is assigned a dedicated intelligent decentralized controller (5) which controls the motor drive (1) such that the prescribed movement tasks are duly performed, characterized in that the decentralized controller (5) is prescribed at least one algorithm for forming a path/time function, and in that in addition to the path data and time data (s1, s2, s3, s4; t1, t2, t3, t4), the central controller (7) transmits at least one item of information (ST1, ST2, ST3, ST4; sH, tH) for forming the path/time function in accordance with the algorithm between the interpolation points (P1 to P4).

2. Method according to Claim 1, characterized in that data on the gradients (ST1 to ST4) of the path/time function at the interpolation points (P1 to P4) are transmitted as additional information.

3. Method according to Claim 1 or 2, characterized in that the position of at least one auxiliary point (PH) not lying on the path curve (B) between the interpolation points (P1, P2) is transmitted as additional information.

4. Method according to Claims 2 and 3, characterized in that the position of the point of intersection of the tangents at the interpolation points (P1, P2) is transmitted as additional information.

5. Method according to one of Claims 1 to 4, characterized in that Bezier curves are used as algorithm for the path/time function.

6. Method according to one of Claims 1 to 5, characterized in that the decentralized controller (5) and path sensors (3) are used to undertake control of the motor drive (1) in order to satisfy the path/time function determined.

7. Method according to one of Claims 1 to 6, characterized in that the decentralized controller (5) is used to control a stepping motor drive with a multiplicity of control steps between the interpolation points (P1 to P4) in accordance with the path/time function determined.

8. Method according to Claim 7, characterized in that the respective instant for the next step of the stepping motor is controlled in accordance with the path/time function determined.

9. Method according to one of Claims 1 to 8, characterized in that before the control of the motor drive (1) by means of the path/time function, a check is carried out as to whether the movement task is within the capability of the motor drive (1), and in that a new calculation of the movement task is initiated by the central controller (7) when the capability of the motor drive (1) would be exceeded.

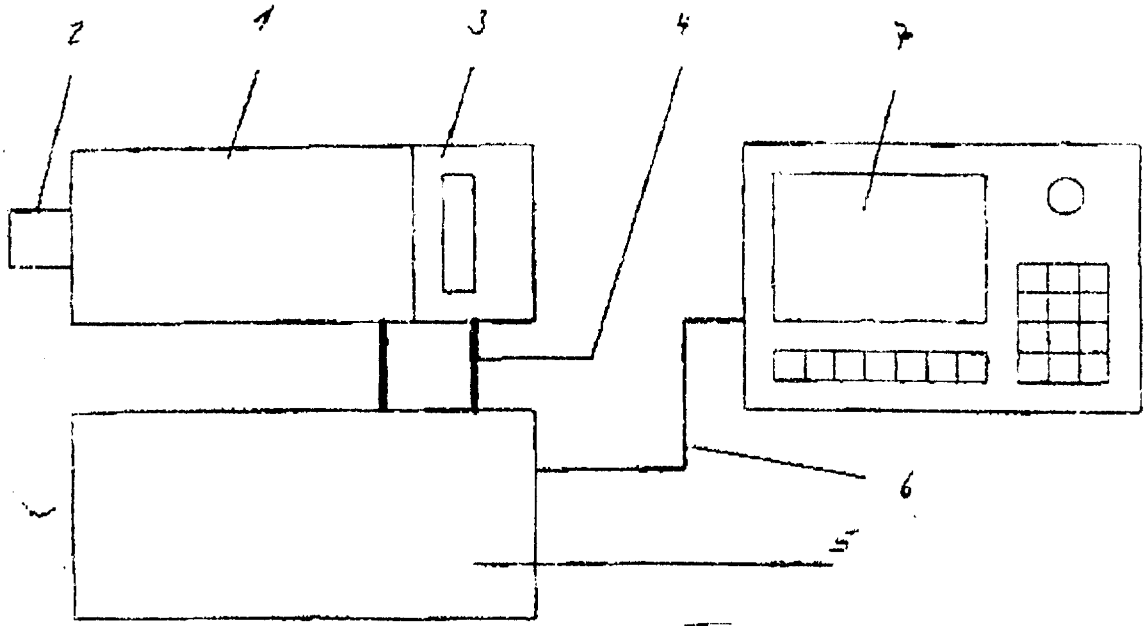


Fig. 1

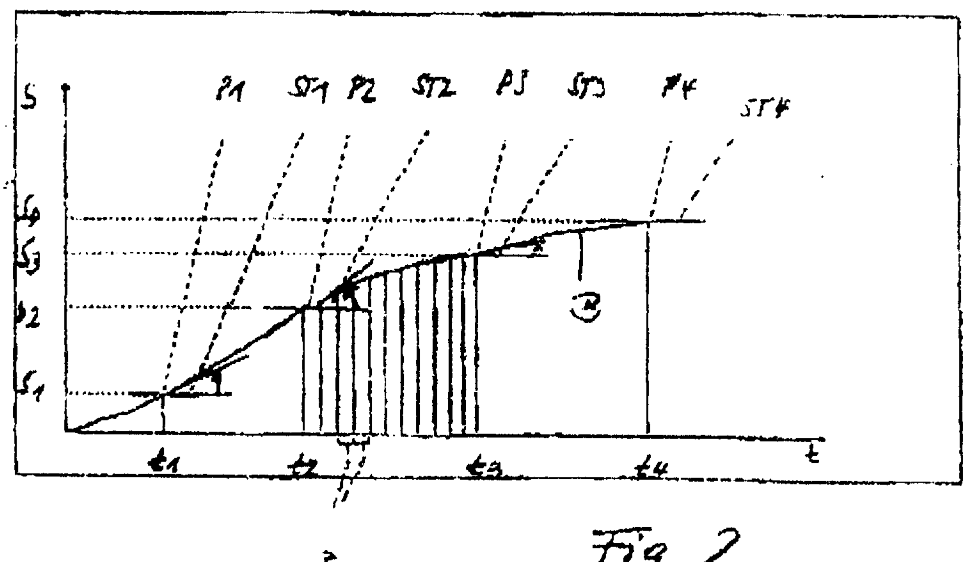


Fig. 2

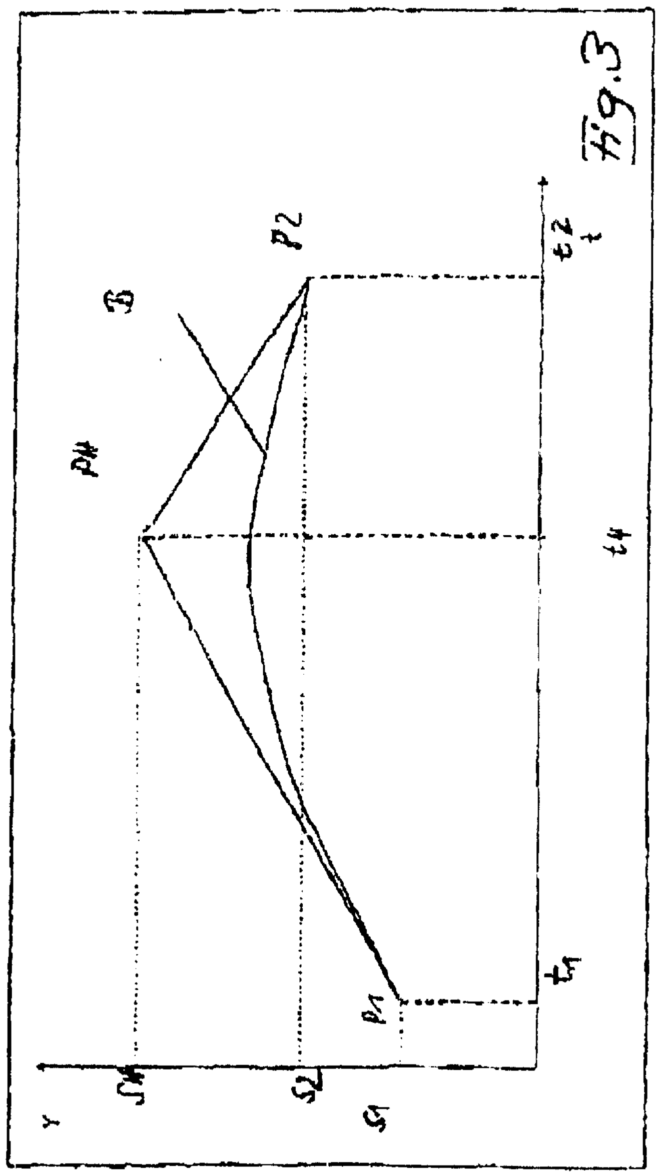
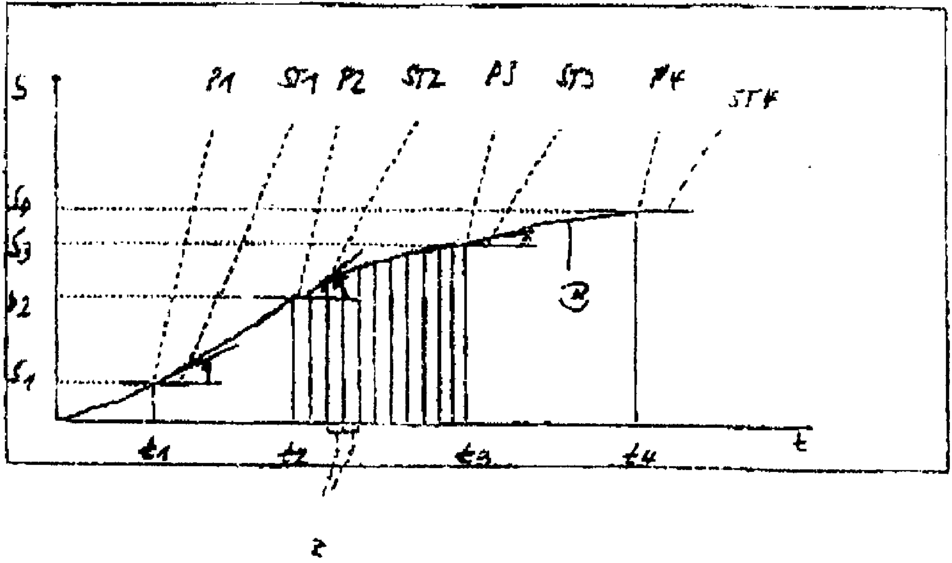


Fig.3



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P1
ST1
P2
ST2
P3
ST3
P4
ST4
S1
t1
t2
t3
t4
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