

Floor Treatment Machine and Method for Treating Floor Surfaces

The invention relates to an automatic floor treatment machine and to a method for treating floor surfaces as well as to a computer program product, which initiates the execution of a method on a program-controlled floor treatment machine.

The current invention relates in particular to machines and to methods for treating floors, the treated floor surface of which is limited by fixed elements, such as the wall sections bordering the floor surface, doors, passageways, or elements, such as columns, inner wall sections or fixed shelves, which are arranged on the floor surface, and, if applicable, by replaceable elements.

Many solutions are known from the prior art, in the case of which automatic floor cleaning machines carry out cleaning processes on floors of buildings independently. There are two approaches, which have their own individual character. In the case of the first approach, the floor surface is passed over at random, for example in that a random change of direction is chosen when striking an obstacle. Due to the fact that a map of the room, which is to be cleaned, and a plan for an advantageous cleaning route is not created, the required storage capacity is small, but the effort for the processing movement is very high. Many areas are passed over several times and a long cleaning time must be provided for cleaning as completely as possible. This method is not suitable for professional cleaning.

In the case of the second approach, the floor surface is mapped as accurately as possible and an advantageous route is determined. The planning of the route is linked to a large amount of computing effort and has to be established by operating personnel using a time-consuming learning procedure. It must be controlled that the planned route is followed in response to the cleaning. In addition, a solution for bypassing obstacles and the subsequent location of the planned route must be provided. These solutions use grids for storing the map of the room, for planning the cleaning route and for storing the cleaned areas. Due to the fact that the resolution of the grid must be as small as possible, correspondingly large amounts of data quantities must be stored and processed. The specifications necessary for avoiding

effort if the area to be treated is not coherent and/or if the cleaning sequence has to be adapted to time specifications and/or to regionally differing cleaning requirements or space conditions.

5 **Summary**

According to a first aspect, the present disclosure refers to a floor treatment machine for treating floor surfaces, comprising a housing, two drive wheels, at least one support wheel, a drive device, a controller, at least one obstacle-recognizing device and comprising a floor treatment device, which ensures that the floor can be treated in a treatment area comprising a predetermined location relative to the wheels, as well as comprising a treatment width perpendicular to the driving direction, wherein the controller encompasses a treatment mode, the treatment mode ensures that on a surface, which is to be treated, groups of driving lines which run next to one another can be swept over by means of the treatment area of the floor treatment machine, wherein a treatment direction with a forwards and backwards orientation is aligned perpendicularly to the route sections the position and alignment of the floor treatment machine in the floor coordinate system is provided by a position detection device, route segments on the driving lines can be driven from starting points to end points each in one driving direction, the driving directions on adjacent driving lines are each oriented in opposite directions, the end points are established in that driving cannot be continued on the respective driving line due to a real or virtual obstacle, which is detected by the obstacle recognition device, for the end points in each case the starting point as well as the end point of the route segment, which was followed, at least one of the states "completely treated" or "incompletely treated" and also a direction information, at least in the case of "incompletely treated" are stored in a route segment storage, wherein it becomes clear from the direction information, in which orientation of the treatment direction incompletely treated areas are present, starting at the corresponding end point, and a contour-following movement, in response to which the floor treatment machine follows the obstacle until it encounters a driving line, can be triggered at the end points for finding new starting points in each case, wherein the contour-following movement starts in the direction of the respective current orientation of the treatment direction, when encountering the driving line, which was followed prior to the contour-following movement, on a route segment, which, according to the route segment storage, has not yet been followed, a new starting point is established at that location and the driving direction of this driving line is chosen, when encountering an adjacent driving line on a route segment, which,

according to the route segment storage, has not yet been followed, a new starting point is established at that location and the driving direction of this adjacent driving line is chosen, when encountering a driving line on a route segment, which, according to the route segment storage, has already been followed, the end of a group of route segments, which run next to one another, is established, wherein the controller then looks for an end point comprising the state "incompletely treated" in the route segment storage and approaches it with a position search movement, so as to tackle a new group of route sections, which run next to one another, starting at this end point in the orientation of the treatment direction stored for this end point, until no end point comprising the state "incompletely treated" is current any longer, characterized in that the controller comprises a planning mode which enables, on a floor surface to be treated, determination of at least two zones, in each zone a first node, and a connection route from at least one zone to a first node of another zone, wherein to determine a zone, at least one section of its zone boundary can be entered as a virtual obstacle, so that a direct connection between the first node of the established zone and the first node of another zone is interrupted by the entered section of the zone boundary because of real and virtual obstacles, and the treatment mode prevents a change of the floor treatment machine from the current zone under treatment to another zone to be treated because of real and virtual obstacles and only permits a drive from this current zone to the first node of the other zone to be treated by canceling the effect of a region of the zone boundary of the current zone arranged as a virtual obstacle between the first nodes of the two zones when an end point having the state "incompletely treated" is no longer present in the current zone after passing over this zone, wherein after reaching the first node of the other zone to be treated, at least one region of the zone boundary of the other zone to be treated is entered as a virtual obstacle, so that an exit from the zone to be treated is prevented until it is completely treated.

According to a second aspect, the present disclosure refers to a method for treating floor surfaces by means of a floor treatment machine, comprising a housing, two drive wheels, at least one support wheel, a drive device, a controller, at least one obstacle-recognizing device and comprising a floor treatment device, which ensures that the floor can be treated in a treatment area comprising a predetermined location relative to the wheels, as well as comprising a treatment width perpendicular to the driving direction, wherein in a treatment mode on a surface, which is to be treated, groups of driving lines, which run next to one another, are swept over by means of the treatment area of the treatment machine and at the same time a treatment direction with forwards and

backwards orientation is aligned perpendicularly to the route sections, the position and alignment of the floor treatment machine in the floor coordinate system are provided by a position detection device, route segments on the driving lines are driven from starting points to end points each in one driving direction, the driving directions on adjacent driving lines are oriented in opposite directions, the end points are established in that driving cannot be continued on the respective driving line due to a real or virtual obstacle, which is detected by an obstacle recognition device, for the end point the starting point as well as the end point of the route segment, which was followed, at least one of the states "completely treated" or "incompletely treated" and at least in the case of "incompletely treated" also a direction information are stored in a route segment storage, wherein it becomes clear from the direction information, in which orientation of the treatment direction incompletely treated areas are present, starting at the corresponding end point, and a contour-following movement, in response to which the floor treatment machine follows the obstacle until it encounters a driving line, is triggered at the end points for finding new starting points in each case, wherein the contour-following movement starts in the direction of the respective current orientation of the treatment direction, when encountering the driving line, which was followed prior to the contour-following movement, on a route segment, which, according to the route segment storage, has not yet been followed, a new starting point is established at that location and the driving direction of this driving line is chosen, when encountering an adjacent driving line on a route segment, which, according to the route segment storage, has not yet been followed, a new starting point is established at that location and the driving direction of this adjacent driving line is chosen, when encountering a driving line on a route segment, which, according to the route segment storage, has already been followed, the end of a group of route segments, which run next to one another, is established, wherein the controller then looks for an end point comprising the state "incompletely treated" in the route segment storage and approaches it with a position search movement, so as to tackle a new group of route sections, which run next to one another, starting at this end point in the orientation of the treatment direction stored for this end point, until no end point comprising the state "incompletely treated" is current any longer, characterized in that in a planning mode, on a floor surface to be treated, at least two zones, in each zone a first node and from at least one zone a connection route to a first node of another zone are determined, wherein to determine a zone, at least one section of its zone boundary is entered as a virtual obstacle, so that a direct connection between the first node of the established zone and the first node of another zone is interrupted by the entered section of the zone boundary during the treatment of the determined zone be-

cause of real and virtual obstacles, and in the treatment mode, a change of the floor treatment machine from the current zone under treatment to another zone to be treated is prevented because of real and virtual obstacles and a drive from this current zone to the first node of the other zone to be treated is only permitted by canceling the effect of
5 a section of the zone boundary of the current zone entered as a virtual obstacle between the first node of the two zones when an end point having the state "incompletely treated" is no longer present in the current zone after passing over this zone, wherein after reaching the first node of the other zone to be treated, at least one section of the zone boundary of the other zone to be treated is used as a virtual obstacle, so that an
10 exit from the zone to be treated is prevented until it is completely treated.

According to a third aspect, the present disclosure refers to a computer program product, which triggers the execution of a method according to the second aspect on a program-controlled floor treatment machine.

15 The task is solved by means of a floor treatment machine comprising the features of the first aspect, by means of a method comprising the features of the second aspect and by means of a computer program product comprising the features of the third aspect. The dependent claims describe alternative or advantageous embodiment alternatives, respectively, which solve further tasks.

When solving the task, it was recognized that there are many situations in which a surface cannot simply be treated in a treatment procedure essentially progressing in one direction. For example, if large sales surfaces comprise areas having different products,
25 it can be that fresh products are filled into the shelves in the morning in one area and therefore in this time travel of a cleaning machine obstructs the filling work, and/or the cleaning machine is obstructed from sufficient progress by the filling work. In areas without refilling work, a cleaning machine could be used much more efficiently, wherein these areas can be formed both by areas of the sales surface without filling work or also
30 by other rooms in the same building. Moreover, it can be that a floor area has to be cleaned after the refilling work, for example, because soiling originates from the refilled products.

Differently soiled areas can occur even on large coherent floor surfaces without obstacles, for example, gymnasium areas at the circles in front of handball goals. Such areas
35 can make cleaning twice or multiple times necessary. It has been recognized in the

scope of the invention that more intensive cleaning of specified areas is to be enabled without the entire surface being cleaned equally intensely. For floor surfaces having traversable minimal obstacles, such as protruding guidelines for the blind, the solution according to the invention is to avoid passing cleaning movements because disturbances on a treatment area abutting the floor can occur during the passing over.

It has been recognized that it is important for the treatment flexibility required in the above examples that zones can be determined which are treated in succession. Moreover, it has been recognized in the scope of the invention that the effort required for the treatment of zones remains as low as possible if the controller does not have to compute routes optimized with great effort in each case for determined zones. Passing over

Patent Claims

1. A floor treatment machine for treating floor surfaces, comprising a housing, two drive wheels, at least one support wheel, a drive device, a controller, at least one obstacle-recognizing device and comprising a floor treatment device, which ensures that the floor can be treated in a treatment area comprising a predetermined location relative to the wheels, as well as comprising a treatment width perpendicular to the driving direction, wherein the controller encompasses a treatment mode,
the treatment mode ensures that on a surface, which is to be treated, groups of driving lines which run next to one another can be swept over by means of the treatment area of the floor treatment machine, wherein a treatment direction with a forwards and backwards orientation is aligned perpendicularly to the route sections
the position and alignment of the floor treatment machine in the floor coordinate system is provided by a position detection device,
route segments on the driving lines can be driven from starting points to end points each in one driving direction,
the driving directions on adjacent driving lines are each oriented in opposite directions,
the end points are established in that driving cannot be continued on the respective driving line due to a real or virtual obstacle, which is detected by the obstacle recognition device,
for the end points in each case the starting point as well as the end point of the route segment, which was followed, at least one of the states “completely treated” or “incompletely treated” and also a direction information, at least in the case of “incompletely treated” are stored in a route segment storage, wherein it becomes clear from the direction information, in which orientation of the treatment direction incompletely treated areas are present, starting at the corresponding end point, and a contour-following movement, in response to which the floor treatment machine follows the obstacle until it encounters a driving line, can be triggered at the end points for finding new starting points in each case, wherein the contour-following movement starts in the direction of the respective current orientation of the treatment direction,

when encountering the driving line, which was followed prior to the contour-following movement, on a route segment, which, according to the route segment storage, has not yet been followed, a new starting point is established at that location and the driving direction of this driving line is chosen,

when encountering an adjacent driving line on a route segment, which, according to the route segment storage, has not yet been followed, a new starting point is established at that location and the driving direction of this adjacent driving line is chosen,

when encountering a driving line on a route segment, which, according to the route segment storage, has already been followed, the end of a group of route segments, which run next to one another, is established, wherein the controller then looks for an end point comprising the state “incompletely treated” in the route segment storage and approaches it with a position search movement, so as to tackle a new group of route sections, which run next to one another, starting at this end point in the orientation of the treatment direction stored for this end point, until no end point comprising the state “incompletely treated” is current any longer,

characterized in that

the controller comprises a planning mode which enables, on a floor surface to be treated, determination of at least two zones, in each zone a first node, and a connection route from at least one zone to a first node of another zone, wherein to determine a zone, at least one section of its zone boundary can be entered as a virtual obstacle, so that a direct connection between the first node of the established zone and the first node of another zone is interrupted by the entered section of the zone boundary because of real and virtual obstacles, and

the treatment mode prevents a change of the floor treatment machine from the current zone under treatment to another zone to be treated because of real and virtual obstacles and only permits a drive from this current zone to the first node of the other zone to be treated by canceling the effect of a region of the zone boundary of the current zone arranged as a virtual obstacle between the first nodes of the two zones when an end point having the state “incompletely treated” is no longer present in the current zone after passing over this zone, wherein after reaching the first node of the other zone to be treated, at least

one region of the zone boundary of the other zone to be treated is entered as a virtual obstacle, so that an exit from the zone to be treated is prevented until it is completely treated.

- 5 2. The floor treatment machine according to claim 1, characterized in that the planning mode enables determination of zones spaced apart from one another, adjoining one another, and also overlapping, wherein at least one region of its zone boundary, preferably also the entire zone boundary, can be entered as a virtual obstacle for each zone and in each case only the virtual obstacles of the presently processed zone are active and therefore zone boundaries of other zones can be
10 passed over.
3. The floor treatment machine according to claim 1 or 2, characterized in that the planning mode allows a treatment direction, which is specified for the treatment
15 mode in the corresponding zone, to be assigned to each first node and thus to the zone which is associated with the first node.
4. The floor treatment machine according to any one of claims 1 to 3, characterized in that in the treatment mode, the floor treatment machine is moved to the first node of
20 a current zone if an end point having the state "incompletely treated" is no longer present in the current zone after passing over this zone and accordingly the change from the current zone to another zone is carried out by means of driving the floor treatment machine from the first node of the current zone to the first node of another zone, wherein the floor treatment device is to be moved into a raised state during
25 the drive between these two first nodes.
5. The floor treatment machine according to claim 4, characterized in that the planning mode enables at least one further node and its sequence on the route between two first nodes to be determined and the treatment mode enables the
30 change from the current zone to another zone to be carried out by means of a drive of the floor treatment machine via the at least one further node according to this sequence.
6. The floor treatment machine according to claim 5, characterized in that the at least
35 one further node can be located on a passage route preferably outside all zones to

- be treated and the treatment mode enables the opening of a door or the triggering of travel using an elevator to be achieved if necessary at this further node.
- 5 7. The floor treatment machine according to any one of claims 4 to 6, characterized in that the planning mode permits a change route between two first nodes to be associated with one or both connection directions and the treatment mode enables the change route to be carried out accordingly in one or both connection directions.
 - 10 8. The floor treatment machine according to any one of claims 1 to 7, characterized in that the treatment mode ensures that the state “completely treated” or “incompletely treated”, which is assigned to a current end point, can be determined by means of the distance from the current end point to the closest starting point on a driving line, which is located in the orientation, which is opposite to the current orientation of the
15 treatment direction, directly next to the driving line comprising the current end point, wherein the state “incompletely treated” is chosen in the case of a distance above a predetermined value.
 - 20 9. The floor treatment machine according to any one of claims 1 to 8, characterized in that the floor treatment device is a cleaning device, preferably comprising at least one brush, a cleaning liquid supply and a suction arrangement, but if necessary comprising a dry vacuum, or a spray suction device or a sweeper.
 - 25 10. A method for treating floor surfaces by means of a floor treatment machine, comprising a housing, two drive wheels, at least one support wheel, a drive device, a controller, at least one obstacle-recognizing device and comprising a floor treatment device, which ensures that the floor can be treated in a treatment area comprising a predetermined location relative to the wheels, as well as comprising a treatment width perpendicular to the driving direction, wherein
30 in a treatment mode on a surface, which is to be treated, groups of driving lines, which run next to one another, are swept over by means of the treatment area of the treatment machine and at the same time a treatment direction with forwards and backwards orientation is aligned perpendicularly to the route sections,
35 the position and alignment of the floor treatment machine in the floor coordinate system are provided by a position detection device,

route segments on the driving lines are driven from starting points to end points
each in one driving direction,
the driving directions on adjacent driving lines are oriented in opposite direc-
tions,
5 the end points are established in that driving cannot be continued on the re-
spective driving line due to a real or virtual obstacle, which is detected by
an obstacle recognition device,
for the end point the starting point as well as the end point of the route seg-
ment, which was followed, at least one of the states "completely treated" or
10 "incompletely treated" and at least in the case of "incompletely treated" al-
so a direction information are stored in a route segment storage , wherein it
becomes clear from the direction information, in which orientation of the
treatment direction incompletely treated areas are present, starting at the
corresponding end point, and
15 a contour-following movement, in response to which the floor treatment ma-
chine follows the obstacle until it encounters a driving line, is triggered at
the end points for finding new starting points in each case, wherein
the contour-following movement starts in the direction of the respective cur-
rent orientation of the treatment direction,
20 when encountering the driving line, which was followed prior to the
contour-following movement, on a route segment, which, accord-
ing to the route segment storage, has not yet been followed, a
new starting point is established at that location and the driving di-
rection of this driving line is chosen,
25 when encountering an adjacent driving line on a route segment, which,
according to the route segment storage, has not yet been fol-
lowed, a new starting point is established at that location and the
driving direction of this adjacent driving line is chosen,
when encountering a driving line on a route segment, which, accord-
30 ing to the route segment storage, has already been followed, the
end of a group of route segments, which run next to one another,
is established, wherein the controller then looks for an end point
comprising the state "incompletely treated" in the route segment
storage and approaches it with a position search movement, so
35 as to tackle a new group of route sections, which run next to one
another, starting at this end point in the orientation of the treat-

ment direction stored for this end point, until no end point comprising the state "incompletely treated" is current any longer,

characterized in that

in a planning mode, on a floor surface to be treated, at least two zones, in each
5 zone a first node and from at least one zone a connection route to a first
node of another zone are determined, wherein to determine a zone, at least
one section of its zone boundary is entered as a virtual obstacle, so that a
direct connection between the first node of the established zone and the first
10 node of another zone is interrupted by the entered section of the zone boundary during the treatment of the determined zone because of real and virtual obstacles, and

in the treatment mode, a change of the floor treatment machine from the
current zone under treatment to another zone to be treated is prevented because of real and virtual obstacles and a drive from this
15 current zone to the first node of the other zone to be treated is only
permitted by canceling the effect of a section of the zone boundary
of the current zone entered as a virtual obstacle between the first
node of the two zones when an end point having the state "incompletely treated" is no longer present in the current zone after passing
20 over this zone, wherein after reaching the first node of the other
zone to be treated, at least one section of the zone boundary of the
other zone to be treated is used as a virtual obstacle, so that an
exit from the zone to be treated is prevented until it is completely
treated.

25 11. The method according to claim 10, characterized in that in the planning mode,
zones spaced apart from one another and/or adjoining one another and/or overlapping
are determined, wherein at least a section of its zone boundary, preferably also
the entire zone boundary, can be entered as a virtual obstacle for each zone
30 and in each case only the virtual obstacles of the presently processed zone are
active and therefore zone boundaries of other zones can be passed over.

12. The method according to claim 10 or 11, characterized in that in the planning
mode, a treatment direction, which is specified for the treatment mode in the corresponding
35 zone, is assigned to each first node and thus to the zone which is associated with the first node.

13. The method according to any one of claims 10 to 12, characterized in that, in the treatment mode, the state “completely treated” or “incompletely treated”, which is to be assigned to a current end point, is determined by means of the distance from the current end point to the closest starting point on a driving line, which is located in the orientation, which is opposite to the current orientation of the treatment direction, directly next to the driving line comprising the current end point, wherein the state “incompletely treated” is chosen in the case of a distance above a predetermined value.
14. A computer program product, which triggers the execution of a method according to any one of claims 10 to 13 on a program-controlled floor treatment machine.