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Fixed-Point Target Control of Library Management Robot: A Linear Decomposition Approach

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Abstract. This paper deals with the problem of fixed-point target control for the library management robot. The objective is to control the bookstore management mobile robot in narrow paths, enabling it to arrive at the specified target location from any initial location along the planned path in the shortest time. First, a localization approach of the point location and attitude angle of the mobile robot is proposed. Second, a linear decomposition control approach is proposed, which decomposes the motion of the bookstore management robot into straight line motion and in-situ rotation, and the dynamic models of the straight line motion and the in-situ rotation are respectively established. Then, according to the linear decomposition models, the fixed-point target control algorithms of straight line motion and in-situ rotation are designed respectively. Finally, a simulation example is conducted to illustrate the effectiveness of the proposed design algorithms.

1. Introduction

With the development of intelligent technology, the use of robots librarians has gradually become the development trend of intelligent library book inventory, for example, the robot library use robots, machines have been welcome library management and service in several large libraries at home and abroad to play an important role. For example, Tsinghua university library develops the real-time smart chat robot to provide various services, including reference service, booking searching, self-learning, and promotes the smart chat robot into the social networking site, and achieves good results [1]. Another example is the Nanjing university library launches a guest robot and a book-counting robot. The book inventory robot is used to check books at the end of the semester. It can check the wrong books through the RFID logo, and report the wrong feedback to the computer screen to remind the staff to return the books.

The application research of intelligent robot in library management is an active research topic. In recent years, the research of this topic has made great progress. For example, using a robot system to help humans browse books of a library from a remote location, which, in general, involves autonomous navigation, environment perception, book manipulation and teleportation [2]. The research results on Internet and robot for remote browsing and remote book borrowing can be seen in literature [3-5]. The interactive robot system in library management for object manipulation is another important research topic. Usually, the interactive robot supporting system supports the robot manipulation in all processing of robot performing the task such as inserting, grasping and drawing [6, 7]. The application examples of the robots in the library also include the robots take books on bookshelves and put books back to bookshelves [8] and user-generated agent with robots such that students can design the contents [9, 10], etc.
With the continuous development of intelligent technology in libraries, in recent years, wheeled mobile robots have been gradually applied to the management of library bookstores [11]. The location of mobile robots in library are usually used radio frequency identification (RFID) technology. For example, in [12] by using RFID long-distance identification ability combined with the close accurate positioning technologies, a mobile robot for automatic search of books in libraries is designed, which can effectively improve the book search efficiency, saves the massive cost. And [13] proposed an obstacle avoidance scheme of a novel mobile robot system for automatic search of books in libraries based on the RFID, which can make the intelligent robot searching the desired books automatically in libraries. In the process of readers borrowing and returning books, library management robots replace librarians to a certain extent, which not only saves manpower, but also improves the efficiency of readers borrowing and returning books.

This paper deals with the problem of fixed-point target control for the bookstore management robot. The objective is to control the bookstore management mobile robot in narrow paths, enabling it to arrive at the specified target location from any initial location along the planned path in the shortest time. First, a localization approach of the point location and attitude angle of the mobile robot is proposed. Second, a linear decomposition control approach is proposed, which decomposes the motion of the bookstore management robot into straight line motion and in-situ rotation, and the dynamic models of the straight line motion and the in-situ rotation are respectively established. Then, according to the linear decomposition models, the fixed-point target control algorithms of straight line motion and in-situ rotation are designed respectively. Finally, a simulation example is conducted to illustrate the effectiveness of the proposed design algorithms.

2. Problem Statement and Point Localization of Mobile Robot

In the process of readers borrowing and returning books, library management robots replace librarians to a certain extent, which not only saves manpower, but also improves the efficiency of readers borrowing and returning books. Therefore, the point target control of the wheeled mobile robot in libraries is an important research topic. In recent years, wheeled robots have been gradually applied to the management of libraries bookstores at home and abroad.

To solve the problem of fixed-point control of mobile robots, we first need to solve the problem of the point localization. In recent years, the research of the point localization has made great progress. For example, [14] presented a point localization method of mobile robots, which collects non-uniformly distributed signal strength to estimate the location of the access point in an indoor environment. In this section, we propose a localization approach of the point location and attitude angle of the bookstore management robot.

According to the narrow characteristics of the paths between bookshelves in libraries, it is assumed that the bookstore management robot can only move straight or turn in situ, and its intention is shown in Figure 1. It is assumed that there are only two motion states in the library management robot: the straight line motion with velocity $v$ (m/s) and Rotated movement in situ with the angular velocity of $\omega$ (rad/s).

![Figure 1. Schematic diagram of a library management robot.](image-url)
driving direction of the robot in a straight line, \( v(t) \) and \( \omega(t) \) represent the straight line velocity and angular velocity of current, respectively. Let \(-\pi < \theta(t) \leq \pi\).

Taking the horizontal bookshelves with vertical passages and library passages with vertical passages as examples, this paper studies the control problem of fixed-point target of mobile bookstore management robot taking books and returning books. The problem of this paper is to design control laws such that the library management robot go to the determined target location from any initial location in the shortest time. Figure 2 shows the library management robot with 4 rows of 3 bookshelves in the library route, the location of \( A \) and \( S \) respectively represent the initial location and the target location of the library management robot.

In general, the library management robot can stop at any initial location \( A \) of the channel, before receiving the work instructions as shown in Figure 2. To realize the fixed-point target control of the bookstore management robot, first of all, we must know the initial location and the target location of the robot. In this paper, we use robot to scan the RFID tag on the book to determine the location of the robot's initial location and the target location. The RFID reader is installed on the side of the library management robot. This paper takes the RFID reader installed on the left side (or right side) of the robot as an example to study the point localization approach of bookstore management robot's initial location and target location's bookstore management robot. It is assumed that the location information of all books is stored in the library information management system. As shown in Figure 3, the RFID tag of the book at the initial location is first read after the robot receives instructions from the current location to the specified target location. Determine the current location of the robot with the read number of the book.

![Figure 2. Schematic diagram of the running route of a bookstore management robot.](image)

![Figure 3. Machine recognition location and attitude.](image)
A localization approach of the point location and attitude of the mobile robot is proposed in this paper, without increasing the hardware cost of the system, only in the robot controller to increase the localization algorithm in the control software. The library electronic map of the library composed of RFID tag information is preinstalled in the Information Management System, the reader's mobile phone, and other terminal equipment.

In the establishment of a kinematic model for the bookstore management robot, the following assumptions are made as follows:

1. The body of the bookstore management robot, the wheel and the robot's motion surface are rigid bodies.
2. All wheels are always in contact with the moving surface.
3. The wheel is pure rolling friction on the moving surface, and there is no lateral sliding.

The problem of fixed-point driving control is to seek a control law \( u(t) \) such that the robot reaches given any target location from any initial location \( (0, T), \) i.e.,

\[
\begin{align*}
    p(0) &= A, \quad p(T) = S \\
    v(T) &= 0, \quad \omega(T) = 0.
\end{align*}
\]

We call the problem described by (1) a fixed-point target control problem for the bookstore management robot.

3. Design of Fixed-Point Target Control Strategy

When the wheeled robot moves between the bookshelves, the process of motion is decomposed into a straight line and a rotated place. In order to keep the library management robot shuttling in the bookshelf, it keeps the minimum turning path, neither bump into the opposite bookcase nor stumble through the bookshelf.

The problem fixed-point target control is studied for the bookstore management robot. According to the narrow characteristics of the paths between bookshelves in libraries, a linear decomposition control method is proposed to solve the fixed-point target problem of the bookstore management robot. The motion process of the library management robot is decomposed into two motion states, namely, straight line motion and in-situ rotation, so as to realize the linear decoupling of fixed-point target problem. According to the linear decomposition model, the control algorithms of straight line motion and in-situ rotation are designed respectively.

By Newton's law, the dynamic models of straight line motion for the library management robot can be described by

\[
\begin{align*}
    \dot{p}(t) &= v(t) \\
    \dot{v}(t) &= a \\
    ma + f(v) &= F(t)
\end{align*}
\]

And the dynamic models of in-situ rotation for the library management robot can be described by

\[
\begin{align*}
    \dot{\theta}(t) &= \omega(t) \\
    \dot{\omega}(t) &= \alpha \\
    J\ddot{\theta}(t) + g(\omega) &= T(t)
\end{align*}
\]

where \( m \) and \( J \) are the mass and inertia of the mobile robot respectively, \( F(t) \) and \( T(t) \) are the forward traction force and the steering torque of the mobile robot respectively, \( f(v) \) is the forward resistance of the mobile robot, \( g(\omega) \) is the steering resistance torque of the mobile robot. Assume that the control inputs are \( F(t) \) and \( T(t) \).
Because the line velocity $v$ and the angular velocity $\omega$ of the mobile robot change little during driving, it is assumed that forward resistance $f(v)$ and steering resistance torque $g(\omega)$ are linear relation to the line velocity $v$ and the angular velocity $\omega$ respectively, i.e., assume that:

$$f(v) = bv(t), \quad g(\omega) = c\omega(t)$$  \hspace{1cm} (4)

where $b$ and $c$ is the known damping coefficients. Substituting (4) into (2) and (3) respectively, one gets:

$$
\begin{align*}
\ddot{p}(t) &= -\frac{b}{m} \dot{p}(t) + \frac{1}{m} F(t) \\
p(t_0) &= p_0, \quad \dot{p}(t_0) = v(t_0)
\end{align*}
$$  \hspace{1cm} (5)

and

$$
\begin{align*}
\ddot{\theta}(t) &= -\frac{c}{J} \dot{\theta}(t) + \frac{1}{J} T(t) \\
\theta(t_0) &= \theta_0, \quad \dot{\theta}(t_0) = \omega(t_0)
\end{align*}
$$  \hspace{1cm} (6)

The motion state of a mobile robot is decomposed into straight line motion and in-situ rotation. The motion state shown in Figure 1 is decomposed into five steps: (i) Straight line motion from initial location $A$ to location $B$; (ii) In-situ rotation from $\theta = 0$ to $\theta = \pi/2$ at location $B$; (iii) Straight line motion from location $B$ to location $C$; (iv) In-situ rotation from $\theta = \pi/2$ to $\theta = 0$ at location $C$; and (v) Straight line motion from initial location $C$ to target location $S$. Therefore, we only need to design the control algorithms of straight line motion and in-situ rotation, respectively.

3.1. Straight line motion

In the straight line motion state, we take the following control strategy. The robot starts with uniform acceleration $a$. When the velocity $v$ reaches the maximum velocity $v_M$, the robot runs at the maximum velocity $v_M$. And the robot stops with uniform acceleration $-a$. Let the distance of straight line motion be $d$, the initial time and stopping time be $t_0$ and $t_f$. We design the control laws of straight line motion in two cases.

(i) When $d > \frac{v_M^2}{a}$, the straight line motion of a mobile robot is decomposed into 3 processes: uniform acceleration starting, uniform driving, and uniform decelerate stopping.

(a) Uniform acceleration starting: in $t \in [t_0, t_1)$, the mobile robot starts with acceleration $a$ until $v(t_1) = v_M$. By $v(t) = a(t-t_0)$, one gets:

$$
\begin{align*}
t_1 &= t_0 + \frac{v_M}{a} \\
v(t) &= a(t-t_0), \quad t \in \left[t_0, t_0 + \frac{v_M}{a}\right]
\end{align*}
$$  \hspace{1cm} (7)

By (2), (5), and (7), it follows:

$$
\begin{align*}
\ddot{p}(t) &= v(t) = a(t-t_0) \\
\ddot{p}(t) &= -\frac{b}{m} \dot{p}(t) + \frac{1}{m} F(t) = a, \quad t \in \left[t_0, t_0 + \frac{v_M}{a}\right]
\end{align*}
$$  \hspace{1cm} (8)
Therefore, the control law

\[ F(t) = a \left[ m + b(t - t_0) \right], \quad t \in \left[ t_0, t_0 + \frac{v_M}{a} \right] \]  \hspace{1cm} (9)

The driving distance \( d_i = \frac{v_M^2}{2a} \).

(b) Uniform driving: in \( t \in [t_1, t_2) \), the mobile robot moves at \( v(t) = v_M \) until the distance to the target location is \( d - d_i - d_2 = \frac{v_M^2}{2a} = d_i \). The driving distance in the uniform driving process is \( d_2 = d - \frac{v_M}{a} = v_M(t_2 - t_1) \). Therefore,

\[ t_2 = t_0 + \frac{d}{v_M} \]  \hspace{1cm} (10)

By (2), (5) and (10), one gets:

\[
\begin{align*}
\dot{p}(t) &= v_M(t) \\
\ddot{p}(t) &= -\frac{b}{m} \dot{p}(t) + \frac{1}{m} F(t) = 0, \quad t \in \left[ t_0, t_0 + \frac{v_M}{a}, t_0 + \frac{d}{v_M} \right]
\end{align*}
\]  \hspace{1cm} (11)

Therefore, the control law

\[ F(t) = b v_M, \quad t \in \left[ t_0, t_0 + \frac{v_M}{a}, t_0 + \frac{d}{v_M} \right] \]  \hspace{1cm} (12)

(c) Uniform decelerate stopping: in \( t \in [t_2, t_f) \), where \( t_f = t_2 + \frac{v_M}{a} \), the mobile robot stops with acceleration \( -a \) until \( v(t_f) = 0 \). By \( v(t) = v_M - a(t - t_2) \), it implies:

\[
\begin{align*}
t_f &= t_2 + \frac{v_M}{a} = t_0 + \frac{d}{v_M} + \frac{v_M}{a} \\
v(t) &= v_M - a(t - t_2) = \frac{ad}{v_M} + v_M - a(t - t_0), \quad t \in \left[ t_0, t_0 + \frac{d}{v_M}, t_0 + \frac{d}{v_M} + \frac{v_M}{a} \right]
\end{align*}
\]  \hspace{1cm} (13)

By (2), (5) and (13), one gets:

\[
\begin{align*}
\dot{p}(t) &= \frac{ad}{v_M} + v_M - a(t - t_0) \\
\ddot{p}(t) &= -\frac{b}{m} \dot{p}(t) + \frac{1}{m} F(t) = -a, \quad t \in \left[ t_0, t_0 + \frac{d}{v_M}, t_0 + \frac{d}{v_M} + \frac{v_M}{a} \right]
\end{align*}
\]  \hspace{1cm} (14)

Therefore, the control law

\[ F(t) = \frac{abd}{v_M} + b v_M - ab(t - t_0) - a m, \quad t \in \left[ t_0, t_0 + \frac{d}{v_M}, t_0 + \frac{d}{v_M} + \frac{v_M}{a} \right] \]  \hspace{1cm} (15)

By (13), one gets the time in the process of straight line motion is:

\[ t_f - t_0 = \frac{d}{v_M} + \frac{v_M}{a} \]  \hspace{1cm} (16)
(ii) When \( d \leq \frac{v_0^2}{a} \), the straight line motion of a mobile robot is decomposed into 2 processes.

(a) Uniform acceleration starting: in \( t \in \left[ t_0, t_1 \right) \), the mobile robot starts with acceleration \( a \) until the driving distance in the starting process is \( d_1 = d/2 \). By \( d_1 = a(t_1 - t_0)^2/2 \), one gets

\[
\begin{align*}
t_1 &= t_0 + \frac{\sqrt{d}}{a} \\
v(t) &= a(t - t_0), & t \in \left[ t_0, t_0 + \frac{\sqrt{d}}{a} \right]
\end{align*}
\]

By (2), (5) and (17), one gets:

\[
\begin{align*}
\dot{p}(t) &= v(t) = a(t - t_0) \\
\ddot{p}(t) &= -\frac{b}{m} \dot{p}(t) + \frac{1}{m} F(t) = a, & t \in \left[ t_0, t_0 + \frac{\sqrt{d}}{a} \right]
\end{align*}
\]

Therefore, the control law

\[
F(t) = a \left[ m + b(t - t_0) \right], & t \in \left[ t_0, t_0 + \frac{\sqrt{d}}{a} \right]
\]

(b) Uniform decelerate stopping: in \( t \in \left[ t_1, t_f \right) \), the mobile robot stops with acceleration \(-a\) until \( v(t_f) = 0 \). By \( v(t_1) = \sqrt{ad} \) and \( v(t) = v(t_1) - a(t - t_1) \), one gets

\[
\begin{align*}
t_f &= t_0 + 2\frac{\sqrt{d}}{a} \\
v(t) &= 2\sqrt{ad} - a(t - t_0), & t \in \left[ t_0 + \frac{\sqrt{d}}{a}, t_0 + 2\frac{\sqrt{d}}{a} \right]
\end{align*}
\]

By (2), (5) and (20), it follows:

\[
\begin{align*}
\dot{p}(t) &= 2\sqrt{ad} - a(t - t_0) \\
\ddot{p}(t) &= -\frac{b}{m} \dot{p}(t) + \frac{1}{m} F(t) = -a, & t \in \left[ t_0 + \frac{\sqrt{d}}{a}, t_0 + 2\frac{\sqrt{d}}{a} \right]
\end{align*}
\]

Therefore, the control law

\[
F(t) = 2b\sqrt{ad} - ab(t - t_0) - ma, & t \in \left[ t_0 + \frac{\sqrt{d}}{a}, t_0 + 2\frac{\sqrt{d}}{a} \right]
\]

By (20), one gets the time in the process of straight line motion is:

\[
t_f - t_0 = 2\frac{\sqrt{d}}{a}
\]

3.2. In-situ rotation state
In the in-situ rotation state, let the angle of in-situ rotation be $\pi/2$ (or $-\pi/2$). We take the following control strategy. The robot starts with uniform angular acceleration $\beta$ (or $-\beta$). Let the initial time and stopping time be $t_0$ and $t_f$, respectively. When the rotation angle $\theta(t_i) = \theta(t_0) + \pi/4$ (or $\theta(t_i) = \theta(t_0) - \pi/4$), the robot stops with uniform angular acceleration $-\beta$ (or $\beta$) until $\theta(t_f) = \theta(t_0) + \pi/2$ (or $\theta(t_f) = \theta(t_0) - \pi/2$). In the following discussion, let the angle of in-situ rotation be $\pi/2$ as an example, we design the control laws of in-situ rotation as follows.

The in-situ rotation of a mobile robot is decomposed into 2 processes: uniform angular acceleration starting and uniform angular decelerate stopping.

(a) Uniform angular acceleration starting: in $t \in [t_0, t_i)$, the mobile robot starts with angular acceleration $\beta$ until the rotation angle $\theta_1(t_i) = \pi/4$. Because $\theta_1(t) = \beta(t-t_0)^2/2$, therefore,

$$
\begin{align*}
  t_i &= t_0 + \frac{\pi}{2\beta} \\
  \omega(t) &= \beta(t-t_0), \quad t \in \left[ t_0, t_0 + \frac{\pi}{2\beta} \right]
\end{align*}
$$

(24)

By (3), (6) and (24), one gets:

$$
\dot{\theta}(t) = -c J \beta(t-t_0) + \frac{1}{J} M(t) = \beta, \quad t \in \left[ t_0, t_0 + \frac{\pi}{2\beta} \right]
$$

(25)

Therefore, the control law

$$
T(t) = \beta \left[ J + c(t-t_0) \right], \quad t \in \left[ t_0, t_0 + \frac{\pi}{2\beta} \right]
$$

(26)

(b) Uniform angular decelerate stopping: in $t \in [t_i, t_f)$, the mobile robot stops with angular acceleration $-\beta$ until the rotation angle $\theta_2(t_f) = \pi/4$. Because $\omega(t) = \omega(t_i) - \beta(t-t_i)$, $\omega(t_i) = \sqrt{ \frac{\pi \beta}{2} }$, and $\omega(t_f) = 0$, it implies:

$$
\begin{align*}
  t_f &= t_0 + \sqrt{\frac{2\pi}{\beta}} \\
  \omega(t) &= \sqrt{2\pi \beta} - \beta(t-t_0), \quad t \in \left[ t_0 + \frac{\pi}{2\beta}, t_0 + \sqrt{\frac{2\pi}{\beta}} \right]
\end{align*}
$$

(27)

By (3), (6) and (27), one gets:

$$
\dot{\theta}(t) = -\frac{c}{J} \left[ \sqrt{2\pi \beta} - \beta(t-t_0) \right] + \frac{1}{J} M(t) = -\beta, \quad t \in \left[ t_0 + \sqrt{\frac{\pi}{2\beta}}, t_0 + \sqrt{\frac{2\pi}{\beta}} \right]
$$

(28)

Therefore, the control law

$$
T(t) = \beta \left[ J + c(t-t_0) \right], \quad t \in \left[ t_0 + \sqrt{\frac{\pi}{2\beta}}, t_0 + \sqrt{\frac{2\pi}{\beta}} \right]
$$
\[
T(t) = c\sqrt{2\pi\beta} - \beta\left[J + c(t - t_0)\right], \quad t \in \left[t_0 + \frac{\pi}{2\beta}, t_0 + \frac{2\pi}{\beta}\right]
\]

(29)

By (27), one gets the time in the process of straight line motion is:

\[
t_f - t_0 = \frac{2\pi}{\beta}
\]

(30)

In the following, we study the linear decomposition control strategy of the fixed target control of the mobile robot in several cases.

4. Simulation Example

Consider the problem of the point target control for the wheeled mobile robot in libraries as shown in Figure 2, where the distances from the initial location \( A \) to the location \( B \), from the location \( B \) to the location \( C \), and from the location \( C \) to the target location \( S \) are \( D_1 = 10 \text{ (m)} \), \( D_2 = 6 \text{ (m)} \), and \( D_3 = 2 \text{ (m)} \), respectively. The maximum velocity \( v_M = 2 \text{ (m/s)} \), the acceleration \( a = 1 \text{ (m/s}^2) \), the angular acceleration \( \beta = \pi/8 \text{ (rad/s}^2) \), the mass \( m = 10 \text{ (kg)} \) and the inertia \( J = 2 \text{ (kg} \cdot \text{m}^2) \), the damping coefficient \( b = 2 \text{ (kg/s)} \) and the damping coefficient \( c = 1 \text{ (kg} \cdot \text{m/s}) \).

The control process is decomposed into 5 steps:

Step 1. The straight line motion from initial location \( A \) to location \( B \).
By control laws (9), (12), and (15), one gets the control law:

\[
F(t) = \begin{cases} 
10 + 2t, & t \in [0, 2) \\
4, & t \in [2, 5) \\
4 - 2t, & t \in [5, 7) 
\end{cases}
T(t) = 0, \quad t \in [0, 7)
\]

(31)

Step 2. The in-situ rotation at location \( B \).
By control laws (26) and (29), one gets the control law:

\[
F(t) = 0, \quad t \in [7, 11)
T(t) = \begin{cases} 
\frac{\pi}{8}(t - 5), & t \in [7, 9) \\
\frac{\pi}{8}(9 - t), & t \in [9, 11)
\end{cases}
\]

(32)

Step 3. The straight line motion from location \( B \) to location \( C \).
By control laws (9), (12), and (15), one gets the control law:

\[
F(t) = \begin{cases} 
2t - 12, & t \in [11, 13) \\
4, & t \in [13, 14) \\
22 - 2t, & t \in [14, 16)
\end{cases}
T(t) = 0, \quad t \in [11, 16)
\]

(33)

Step 4. The in-situ rotation at location \( C \).
By control laws (26) and (29), one gets the control law:
\[ F(t) = 0, \quad t \in [16, 20) \]
\[ T(t) = \begin{cases} \frac{\pi}{8} (14-t), & t \in [16, 18) \\ \frac{\pi}{8} (t-18), & t \in [18, 20) \end{cases} \]  \hspace{1cm} (34)

Step 5. The straight line motion from location \( C \) to target location \( S \).

By control laws (19) and (22), one gets the control law:

\[ F(t) = \begin{cases} 2(t-15), & t \in [20, 20+\sqrt{2}) \\ F(t) = 30+4\sqrt{2}-2t, & t \in [20+\sqrt{2}, 20+2\sqrt{2}) \end{cases} \]
\[ T(t) = 0, \quad t \in [20, 20+2\sqrt{2}) \]  \hspace{1cm} (35)

Figure 4 and Figure 5 show the simulation curves of the line velocity and the angular velocity respectively. From Figure 4 and Figure 5, it can be concluded that the fixed-point target control laws in (31)-(35) can effectively decompose the velocity of the bookstore management robot into the line velocity of straight line motion and the angular velocity of in-situ rotation.

![Figure 4. Straight line motion velocity curve.](image1.png)

![Figure 5. Angular velocity curve.](image2.png)

Figure 6 and Figure 7 show the driving distance curve and attitude angle curve for the bookstore management robot respectively. From Figure 6 and Figure 7, it can be concluded that the fixed-point
target control laws in (31)-(35) can effectively control the location and the attitude angle of bookstore management robot in the motion state.

Figure 6. Driving distance curve.

Figure 7. Attitude angle curve.

5. Conclusions
This paper has considered the problem of fixed-point target control for the library management robot. A localization approach of the point location and attitude angle of the mobile robot has been presented. According to the narrow characteristics of the paths between bookshelves in libraries, a linear decomposition control approach has been proposed, which decomposes the motion of the bookstore management robot into straight line motion and in-situ rotation, and the dynamic models of the straight line motion and the in-situ rotation have been respectively established. According to the linear decomposition models, the fixed-point target control algorithms of straight line motion and in-situ rotation have been designed respectively.

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